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EDITORIAL.

ITEMS AND NOVELTIES.

The Spiral Pump.—It is with much pleasure we notice the great improvements Mr. Airy has just made in an hydraulic machine of a very remarkable character, hitherto but little understood. Although the spiral pump—as Mr. Airy states at the outset of his valuable little work on the subject now under review—"was invented more than a century ago by Andreas Wirz, the tin worker of Zurich, and was afterwards made the subject of theoretical investigation by Bernoulli and Eylelwein, and in spite of the unqualified approbation bestowed upon it by all who have studied its action, the machine has been practically ignored, and as a consequence it has not received that attention to mechanical details which so greatly tends to the improvement of a machine; indeed it does not appear that more than four working specimens have ever been constructed."

The reason why so little progress has hitherto been made in the improvement of the machine is, in the opinion of the author, due to the rudeness of its construction, and we venture to add—what Mr. Airy's modesty would not allow him to do—to the very complicated nature of the theoretical investigation involved in the action of fluids moving through spiral channels, a subject Mr. Airy has evidently thoroughly investigated and made himself master of. It is gratifying, indeed, to observe that the author in dealing with this subject is able to bring to bear upon it not only the attainments of a high order of mathematical knowledge, which, as the son of the Astronomer Royal, we might perhaps naturally look for, but that thorough practical knowledge of mechanics, which we know Mr. Airy has acquired—in the only way it can be properly acquired—by going through the usual apprenticeship of the workshops.

In addition to the causes just referred to, as operating against the more general use of the spiral pump, may be added the great irregularity which has hitherto attended its working, arising from the discharge of both air and water through the vertical pipe, and the difficulty of making good the water-tight joint. Both these difficulties have, it will be seen, been successfully overcome by Mr. Airy; in the first place by the addition of a separate chamber to receive the alternate discharges of air and water through the spiral coil; and secondly, by the simple and ingenious form of leather joint he has adopted. By these means, and by carefully investigating the theory of the principles involved in its action, in which he has been materially assisted in his preliminary investigations by the use of a model with glass coils, the author has converted, what has hitherto been but of little practical utility, into a highly effective hydraulic machine, capable of raising water to great elevations, and under many circumstances, where there is an abundance of water supply even of a very low fall, it is easy to see that it is capable of most useful and economical application.

The following extracts and illustrations will enable our readers readily to understand the principle upon which these improved spiral pumps are worked; but for a great deal of other very interesting and valuable information in regard to it, we would refer them to the work itself:—*

The spiral pump is constructed as follows: A metal pipe is coiled

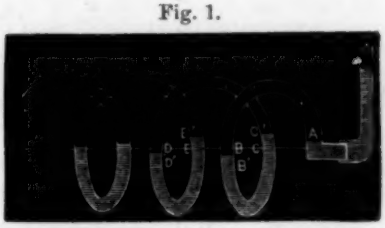
* The Spiral Pump, applied as a Force Pump, &c., by W. Airy, B. A. &c. Willis Southeran & Co., London.

round a cylindrical or conical drum, which is placed with its axis horizontal; this drum is carried by means of two axial pivots; one, a solid gudgeon, running in fixed blocks, and carrying on its end a crank, by means of which the drum can be turned; the other, a strong pipe leading into the curved end of an upright pipe, in which it turns by means of a water-tight joint; one end of the metal pipe on the drum is left open, while the other end is led into the side of the horizontal pipe-gudgeon above described, and soldered to it at the joint.

If the above machine be erected at the surface of a reservoir of water, and so placed that the drum is more or less immersed, then, as the drum is turned, the open end of the pipe that is coiled on the drum takes in a portion of air and a portion of water at every revolution; and when the drum has been turned as many times as there are coils of the pipe upon it, then the pipe on the drum is full of these fluids in regular order, the water in each coil lying at the bottom of the coil, and the air at the top (the quantity of each depending upon the depth of immersion of the drum). If now the drum be still turned, the water and air in the last coil are discharged into the horizontal pipe gudgeon of the machine, and by it into the vertical pipe; and at every additional turn of the drum an additional discharge of air and water takes place into the vertical pipe; the air at once rises to the surface and escapes, but the water remains in the vertical pipe, and establishes a column of fluid, which is supported as follows:—

Suppose that all the coils of the machine have been filled as above described, and that at the next turn of the drum, water will be discharged into the vertical pipe; also suppose that the drum is cylindrical, and is immersed to half its depth in the reservoir, so that the quantities of air and water in each coil are equal, then the position of the fluids will be as shown in Fig. 1; the drum has received the additional turn, and a charge of water has been delivered into the vertical pipe, in consequence of which the water has risen in that pipe, and a pressure column is established. The pressure of this column acting upon the surface of the air at A, and transmitting its pressure by means of the air in A B to the surface of the water at B, tilts up the column of water, B C, so as to

Fig. 1.



make it assume the position B′ C′, and thus establishes a small column of water (equal to the difference of level of B′ and C′) tending to balance the water column in the vertical pipe. At the same time the water column, B′ C′, transmits the pressure (lessened however by the portion which it carries itself) by means of the air in C′ D to the water surface in the next coil at D, and the water column in this coil in like manner is tilted up into the position D′ E′, and supports a portion of the column in the vertical pipe; and the same is repeated in all the coils on the drum. These operations must not, however, be understood to follow one another in sequence, but all take place simultaneously; the water column in every coil is tilted up a little, that nearest to the vertical pipe being tilted most, and that nearest to the in-take mouth least; and the sum of the columns of support thus gained in the coils of the pipe is equal to the column in the vertical pipe; and thus equilibrium is maintained.

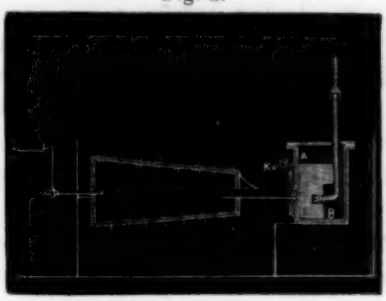
Let now the drum be further turned. Then more water is discharged into the vertical pipe, and a higher column has to be supported; and, as above described, each of the water columns in the coils will be further tilted up, the coil nearest the vertical pipe taking the greatest share of this additional tilting, and the coil nearest to the in-take mouth the least. Since, then, the water column in the coil nearest to the vertical pipe, receives always the largest share of the work of support, it is clear that the upper surface of this column will always stand higher than that of any other of the columns; and in the progress of turning it will at last arrive at the top of its coil.

If, now, the drum be further turned, the water in the last coil being incapable of doing more towards the work of support, will simply overflow into the coil next behind it, and the columns in the succeeding coils will arrange themselves (as above described), to support the additional column in the vertical pipe. In due course of time the upper surface of the water column in the last coil but one will arrive at the top of the coil; and then this column also is performing its maximum duty, and, on the machine being further turned, overflows into the coil behind it. In this way the columns in all the coils are in succession brought to their position of maximum duty, the column in the vertical pipe constantly mounting higher and higher; and finally, when the columns in all the coils are working at their maximum duty, the machine is lifting to the greatest height which it can accomplish. If now the drum be

turned the water is delivered backwards by the above-mentioned system of overflow throughout the coils just as fast as it is discharged into the vertical pipe, and no increment of height is attained. * * *

Thus far it has been assumed that the air and water are both discharged immediately into the vertical pipe; and it is in this way that all the working pumps of this kind have been constructed. But there is great inconvenience in allowing air and water to go up the same pipe; the water is discharged irregularly, with noise and shocks, and is charged with air bubbles. Also there is special inconvenience in making the water-tight joint (the only joint in the whole machine), in the curved end of the vertical pipe. To remedy these evils, the author devised the arrangement exhibited in Fig. 2, by means of which the machine has been made to work with remarkable uniformity and success. A B is an air-tight box, and the pipe-gudgeon, C D is led into the side of A B by a water-tight joint. This joint is simple and exceedingly tight; it is merely a single thickness of leather, in which a hole is cut somewhat smaller than the pipe; the leather being secured to the outside of the box, as shown in the figure, the end of the pipe is forced through the hole in the leather, which thus is somewhat coned, and its edge wraps close against the pipe; the pressure of the water acting on the side of this leather cone always tends to secure the joint, which is so tight that it does not let through a drop of water; in this joint the pipe turns with very little friction compared with that of a stuffing-box. E F is the vertical pipe; its lower end is bell-mouthed, to avoid loss of head by contraction of the fluid, and it is stepped on a block at the bottom of the box; at the top is a spout to deliver the water. K is a tap, the object of which will be soon described.

Fig. 2.



Suppose the tap, K, closed; then, as the drum is turned, air and water are poured into the box; the air, as fast as it enters, ascends to the top of the box, while the water remains below, and is forced up the vertical pipe, as already described.

In this state, the air is of great value, as the upper part of the

box then forms an air-chest (as in a fire-engine), and the expansive force of the air under pressure ensures a regular and even flow of water from the spout at the top of the vertical pipe.

It thus appears that the height to which these machines can force water is determinable simply by the number and size of the coils. The author next proceeds to show how the maximum effect varies in the proportion in which the air and water are alternately taken in at the mouth of the coil, and how the conical form of drum is preferable to the cylindrical in counteracting the prejudicial effects due to the compression of the air in the coils; the singular phenomenon of regurgitation is then noticed and explained. The adaptation of the horn to the intake-mouth, as originally applied by Wirz, the inventor, is then considered by the author, and also the curious effect it has on the arrangement of the air and water in the coils. In the Appendix full information is given for determining the number of coils for the required height, together with a great deal of other valuable data relating to the subject.

Before referring to the subject of the general application of this machine, we would just say a word in regard to a very ingenious and beautiful application of this principle of the spiral pump, referred to in the work, as being the invention of the author's brother, Mr. H. Airy; in this machine, which is appropriately called a mercury pump, that fluid is substituted for the air, and plays a very important function in its action. Owing to its much greater specific gravity, the mercury column only needs to be one-thirteenth of the height of the water column, and the description of the machine very clearly shows how ingeniously, by means of a very small quantity of mercury which is made to circulate through the coils, a continued stream of water is lifted to a very considerable height. The use of such a machine is of course but of limited application; but for hall and garden fountains, and small fancy jets of perfumed water, &c., no more suitable and effective machine could be desired.

With regard to the advantages of the spiral pump, and the scope for its useful application, we cannot do better than conclude our notice with the well put observations of the author himself on this subject:—

"The advantages of it are numerous and important. Its chief recommendation lies in the simplicity of its action, and the fewness of its parts; there are no sliding valves or other moving pieces

liable to expensive repairs, and the one water-tight joint is simple, safe, and easily renewed without skilled labor. The friction may be reduced to a very small amount, for since the drum is always more or less immersed, it will be proper to make the drum hollow and water-tight, so that by proper adjustment of its size, weight, &c., it shall float in the reservoir without bearing at all on the gudgeons. The friction of the water in the pipes is of course unavoidable, but except the velocity of rotation be very great (and this will not be advisable in any case), the friction will not be very considerable.

"The application of the machine would seem chiefly to lie in the lifting of moderate quantities of water to a considerable height, as, for example, the supply of water for domestic purposes from a stream or spring at a considerable distance below the dwellings to be supplied; if there is any fall of water, the machine could be conveniently driven by water-power, and with far greater economy than the hydraulic ram. In such a position its value would be peculiarly felt, as the stoppage of house supply is exceedingly objectionable, and this machine could scarcely anyhow get out of order except at the water-tight joint, which is renewed in a few minutes."—*Engineering.*

Tapping a Mine.—The circumstances under which this application took place are thus detailed in the *Newcastle Daily Chronicle*: A particular seam of coal was subject to inundation from a large feeder of water, rendering a great amount of pumping power necessary in the working of the coal. The water was found to proceed from an old pit, which had been sunk many years ago to the deeper and more valuable seams, and had become gradually filled with rubbish, consisting principally of old shaft timber, stones, &c., up to the level of the seam in question, thus forming an obstruction to the water, which otherwise would have passed down the shaft and found an outlet at a lower level by means of old workings. Numerous attempts had previously been made by boring to pass the water down, but without success, the timber seeming to form an impassable barrier. Mr. Hall being favorably impressed with the success which had attended Mr. Norton's patent for sinking wells, resolved to test its capabilities in passing through a material which had been proved impenetrable to the common bore rod. Mr. Ridley, from Messrs. Mather & Armstrong, of Newcastle, licencers of the patent, undertook the management of the apparatus. An 80 pound weight and a 1¼-inch tube were used. When two hours had expired from

the commencement of the operation, the tube was found to have been driven a distance of 20 feet, the speed varying considerably. The succeeding 15 feet were overcome in four hours. At this point the process became much slower, but never stationary, the next 3 feet requiring two hours labor; then 3 feet at a considerably increased speed, occupying only half an hour. The water was now laid on to the pipe and found to pass freely, and the driving was discontinued, 41 feet having been overcome in eight hours and a half. Had it been necessary, it seemed quite possible to have driven the tubes to the extreme depth of the sinking. The experiment proved a great success, and the pipes are now doing good work, and will constitute a material saving in the working of the seam, the purpose they serve being precisely the reverse of that for which they were originally intended by the patentee. It is stated that the pit contained the *debris* of one hundred fathoms of ordinary shaft bratticing, and several hundred tons of walling stones, rendered solid and compact by a quantity of ordinary pit waste-heap falling away from the surface.

A Fog Whistle, recently erected on Cape Fourcher, Yarmouth Harbor, Nova Scotia, is said to be the most powerful signal in North America, and can be heard fifteen miles in calm weather; in stormy weather five to eight miles; with the wind twenty-five miles; against the wind five to eight miles. It has been heard inland with the wind twenty-five to thirty miles.

Pin Making.—It is estimated that 1,000 persons are employed in Birmingham in the manufacture of pins, hair-pins, hooks, eyes, thimbles and eyelets. Messrs. Edlesten & Williams alone use three tons of wire weekly in pin making, and Messrs. Eridge & Merritt, C. Iles, Phipson & Son, and other makers, would probably augment the total consumption of brass wire to twelve tons per week. At a moderate estimate, the number of pins manufactured weekly in Birmingham exceeds 200,000,000.

Street Railway in London.—At a meeting of the Board of Works last Friday it was determined that before sanctioning any scheme of tramways in the streets of the metropolis it would be desirable to have an experimental line between Westminster Bridge and Kennington Park, and the solicitor of the Board was directed to confer with the promoters of the bill before Parliament with a view of making arrangements for that purpose.

Old and New Coal.—Our attention has been lately drawn to a curious observation which stands, as yet, as a fact without a sufficient reason. In one case, where hard coal is used in large quantities for purposes of mere evaporation, it appears that some which has been kept on hand in open piles for five or six months, is less effective by from 13 to 15 per cent. than that freshly mined. A similar result, corresponding even in the per centage of deterioration, appears in another report from a smelting furnace. The deterioration from decrepitation, caused by absorption of water, is of course well known, but does not seem to apply to these cases.

Ship Canal across France.—The project of establishing through the valley of the Garonne (France) a canal for large navigation, to connect the ocean to the Mediterranean has been often mooted; but there is now a new plan for this undertaking, under the auspices of M. Staal de Magnoncourt, late peer of France. The proposed canal is to admit not only merchant ships of the heaviest tonnage, but also men of war and transatlantic steamers. A port is to be established in the Gironde, just below Bordeaux, and another on the Mediterranean. The cost of the scheme is estimated at 442,000,000 francs, and the cutting of the canal would occupy six years. The plan, if carried out, will materially shorten the navigable communication between England, the north of Europe and India, for it will, in fact, be a continuation of the Suez Canal.

A Cement for Joining Leather, sufficiently strong to be used for driving-belts and boot soles, may be found extremely useful. Such a cement is said by Stubenrauch to be made by mixing ten parts of bisulphide of carbon with one part of oil of turpentine, and dissolving in the mixture sufficient gutta-percha to produce a thick treacly fluid. Before it is employed, the surfaces of leather to be joined must be carefully freed from grease, and smoothed with a hot iron. The cement is then laid on both surfaces, which are now placed together, and kept firmly pressed until the cement is perfectly dry. It is obvious that boots, with soles stuck on in this way, must not be put near a fire.

Eighteen Cornish Engines were reported last month. These consumed 1,468 tons of coal, and lifted 11·7 million tons of water ten fathoms high. Average duty 53,700,000 pounds lifted 1 foot high by the consumption of 112 pounds of coal, or 479,000 foot-pounds per pound of coal. Seven engines exceeded the average duty.

Patents.—The number of visitors to the Patent Office Museum, South Kensington, for the week ending March 27, was 5,377. Total number since the opening of the Museum, free daily (May 12, 1858), 1,527,444.

Accident to a Bridge.—One of those frightful accidents which unfortunately so often accompany the carrying on of great public works occurred last Tuesday at Saltburn-by-the-Sea. An iron bridge 100 feet in length across the famous glen along which Sheltonbeck runs to the coast, was nearly completed, when an immense iron girder slipped from its holding and knocked down one of the piers, killing three men.

Silk Raising.—The *San Francisco Herald* says that those engaged in the culture of silk in California have grown no less than 1,175,000 mulberry trees. They are apportioned as follows: Los Angeles, 50,000; Santa Barbara, 100,000; Santa Clara, 150,000; Nevada, 50,000; Sacramenta, 425,000; Yolo, 400,000. The total production of cocoons, in 1868, amounted to 1,350,000, equivalent to 1,917 pounds, allowing 704 cocoons to the pound, representing a cash value of $3,676·75. To be added to this was the egg crop of 7,250 ounces, commanding in the market $8 per ounce, amounting $58,800. There will be a vast increase in the production of cocoons this year, as three cocooneries will hatch 600 ounces of eggs, sufficient to produce 18,000,000 cocoons.

Iron Analysis.—Gintl gives a very easy method of determining the impurities in cast iron. It is applied by him to the estimation of the sulphur contained in the iron; but, as will be seen, it is available for the separation and determination of most of the usual impurities. The iron is reduced to as minute a state of division as possible, and is then treated with a strong solution of perchloride of iron, as nearly neutral as possible. The mixture is kept heated for ten or twelve hours, at the end of which time almost all the iron will be found to have dissolved, leaving, as a residue, the carbon, sulphur, phosphorus and silicum, together with the little iron left undissolved. This residue has only to be well washed, oxidized and dissolved, and the sulphur estimated as sulphate of baryta. The exact plan directed by the author is to introduce the residue and filter into a porcelain crucible, having, at the bottom, three parts of nitrate of potash and one part of hydrate of potash; heat to fusion, dissolve and precipitate with chloride of barium. The phosphorus and silica will be contained in the same solution, and can be determined separately.

Magnesium-Light Signal Apparatus.—The Navy Department, on recommendation of the Vice Admiral, it is understood, have commenced ordering the "Magnesium-Light Signal Apparatus," designed by First Assistant Engineer, R. H. Thurston, U. S. Navy.

By this apparatus, signals are made with twice the rapidity and at less than *one-tenth* the expense of the old method of Coston colored fires. It is much more effective than the Colomb-Bolton apparatus, on which the British Government has recently expended some £15,000, as its light is not obscured by either the metal gauze or the smoke of burning resin, which are so objectionable in the English apparatus.

The U. S. Steamer "Juniata," fitting out at this port to join the European squadron, is supplied with the new apparatus.

The Eclipse of August 7th.—We are happy to learn, that, though a variety of unfortunate circumstances will prevent Mr. Rutherfurd, Dr. Draper, and four other experienced celestial photographers, from assisting in the observation of the coming eclipse, the great and rare opportunity will be well improved, notwithstanding. Thus, Dr. Curtis, with the Annapolis, 7½-inch Equatorial, and a corps of assistants from the Washington Observatory, is already at Des Moines, and has succeeded in making excellent sun-pictures, showing details of spots and faculæ, by way of practice.

Professor Morton has also organized a triple party, in this city, under the auspices of the Nautical Almanac Office, and has secured the High School Equatorial of 6-inch aperture, and 10 feet focal length (by Merz & Mahler, successors to Fraunhofer), with clockwork driver. The Gettysburg Equatorial, which is a duplicate of this, and a 4-inch telescope, by Dolland, belonging to the University of Pennsylvania.

Through the kindness of Mr. Scott, of the Pennsylvania Railroad, transportation in a special car, to their destination at Burlington, Iowa, and its vicinity, has been obtained for the party and instruments.

The entire party will consist of the following gentlemen:

Professor Henry Morton, Franklin Institute, Philadelphia; Professor A. M. Mayer, Lehigh University, Bethlehem; Professor C. F. Himes, Dickinson College, Carlisle; Mr. W. J. Baker, Buffalo, New York; Mr. E. L. Wilson, Mr. O. H. Willard, Mr. J. Mahoney, Mr. William Long, Mr. H. C. Phillips, Mr. J. Zentmayer, Mr. J. C.

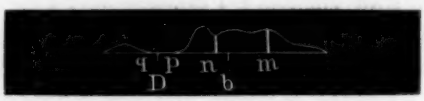
Browne, Mr. E. Moelling, Mr. O. H. Kendall, Mr. James Cremer, Philadelphia, Pa.

This will constitute the photographic portion of the party, allowing five operators in all to each instrument. Professor J. H. C. Coffin, of the Nautical Almanac Office, will meet this party at Burlington, with an Astronomical Corps, and Professor E. C. Pickering, of the Massachusetts Institute of Technology, will go with them to make physical observations. Also Professor James McClune, the astronomer of the High School, will accompany the Philadelphia party, with instruments for astronomical work. The various telescopes have been fitted with eye-pieces of special construction and instantaneous exposure slides by Mr. Zentmayer, and with light cameras furnished by the American Optical Company, New York.

There will also be taken a Chronograph from the Washington Observatory (which has been put in excellent order) by Messrs. Chester & Patrick of this city, by means of which the dates of exposure of the various partial-phase pictures may be actually recorded and thus rendered of infinite value as astronomical observations.

A temporary observatory has been constructed in West Philadelphia, on a very convenient location, kindly placed at the disposal of the party by Mr. John Sellers, and regular drilling in the various manipulations required is being carried on there, and will continue until the time for starting arrives, which will be on the 2d of August.

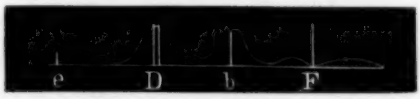
The Spectrum of the Planet Uranus.—To his astonishing discovery of vapor of water in the vicinity of sun-spots, noticed in our last number, Father Secchi has added another spectroscopic discovery fully as remarkable, namely, that the light which comes to us from Uranus differs very much from that reflected by the other planets. In a number of the *Comptes Rendus* just received, (Vol. LXVIII, page 761,) we find an account to this effect. Having turned the spectroscope by chance upon this planet, then appearing as a star of the sixth magnitude, he obtained in place of the normal solar spectrum which be expected, one whose principal characteristics are indicated by the accompanying diagram, where the intensity of light in various parts is indicated by the height of the curve. The red end of this spectrum is at the left, the violet to the right. The position of the normal sun lines D and *b* is indicated by those letters N and M were two very strong ab-



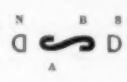
sorption bands located, as here shown, and corresponding to no strong solar lines. The yellow part of the spectrum was entirely wanting, as is indicated between *p* and *q*.

From this we would conclude that this planet has an atmosphere of considerable extent, and generally transparent, but absorptive of certain rays and of all yellow tints, to a considerable degree, and that the rays from the sun are not chiefly reflected to us from clouds or mists in the upper region of such an atmosphere, but penetrate it to a notable depth before they are turned back by reflection. The material of this atmosphere remains to be determined.

The Spectrum of R. Gemini.—This variable star with a spectrum like that of τ Coronæ Borialis, showing *bright* superposed lines indicative of a surrounding luminous envelope of gas, has been further studied by Father Secchi, who, in the paper quoted above, gives a diagram of its spectrum, which we subjoin. The intensity of the general spectrum is here, as before, shown by the curve, while the positions of the bright bands, is indicated by that of the vertical lines. Two of these, C and F, it will be seen, indicate hydrogen, one, *b*, magnesium, and the double line, D, sodium. The first, C and F, are found likewise in the spectrum of τ Coronæ Borialis, but the others are confined to this star.



A New Regulator for the Electric Lamp.—Carié, the inventor of the ice machine which bears his name, has communicated to the Soc. d'Encouragement, a new form of battery, regulator and carbons for the electric light. Of these the most notable is the regulator, whose chief feature is the means by which the varying current gives motion to the carbons. Between the poles of an Electro magnet is an armature, shaped somewhat like the letter S, the spiral curves being so adjusted that the power of the magnet is almost equally efficient in all positions, but tends to bring the central part in line with the poles. This is resisted by the torsion of a steel wire, attached at right angles, to the armature at its centre. Thus, as the current increases in strength, the armature, A B, is drawn into line with N S, the resistance of the spring increasing with the degree of motion. This, by simple connecting machinery, separates the points. If the current diminishes in strength, then the springs conquer, and the motions are all reversed.



Editorial Correspondence.

OUR NEW YORK LETTER.

New York, June 16th.

To-day witnessed the first annual reunion of the members of the American Institute of Engineers, at their rooms No. 63 William Street. It was an interesting event to all concerned, and will be productive of much good to the profession generally, not only in establishing a warmer personal interest in each other, but also in forming another link in that bond of organization, the Society is striving to attain. The session lasted throughout the day, beginning at eleven o'clock, the morning hours being devoted to the reading of papers and general discussions, which gave way in the afternoon, to a comforting dinner, with those necessary post prandial concomitants, toasts and speeches.

The attendance was large and enthusiastic, many non-resident members coming a great distance in order to be present. The especially honored members were Messrs. J. B. Jervis and S. Whipple. The former, so well known throughout the country as one of the patriarchs of the profession, (now seventy-four years old,) and under whom a regular school of engineers developed, read a most excellent paper upon the general subject of the engineering profession, so replete with ripe experience, and good sound practical sense, that its dissemination among all grades of engineers and railway managers would be of infinite service. Its publication, of course, will shortly follow, and it is to be hoped that the Society will depart from its usual custom of not distributing its publications outside of its own members, and allow this paper of Mr. Jervis to be circulated far and wide among the profession for the good that will surely come of it.

Mr. Whipple, whose name is almost as familiar as that of Mr. Jervis, is in many respects a remarkable man. In 1847, when railways were expanding in every direction, the question of bridge building in its scientific bearing became of the utmost importance. Little was known about trussed girders, or the strength of materials,—and in England they were getting at results in the usual way, viz: by sheer "force and money," an experimental mode American engineers are not able to undertake. At this juncture, Mr. Whipple published two essays on Bridge Building, so clear,

logical and simple of application, that his manner of analysis has been practised to the present time by the best bridge engineers in the country. And not only his analysis, but forms of economical trussing, angles of braces, and general recommendations are elements of the majority of the best beam trusses built in America. It would be interesting to quote the remarks of Mr. Whipple on page 81, upon the "proposal by an eminent English engineer, Mr. Stevenson, to construct a tubular or box bridge over the Menai Straits, out of sheet or plate iron, &c."

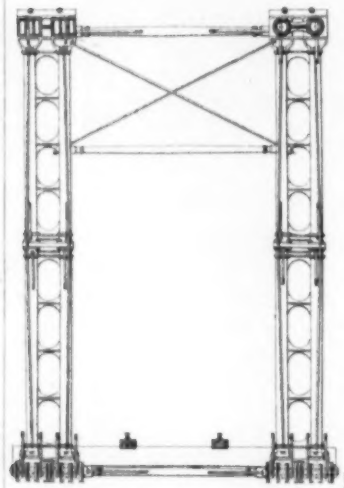
After criticising the enormous waste of material in such a beam, he suggests and estimates for an open built truss, just such a one in the main as would be built now, under the same circumstances. The different processes employed for determining the problem are interesting to note, the one based on costly experiment, supplemented by the highest mathematical talent, the other on a simple consideration and appreciation of the known laws of force, with the little data to be had on the strength of materials. Now mark the result. The first is embodied in as ponderous a piece of iron work (never to be repeated) as the world ever saw. The second, in just such a simple truss as would in principle be built to-day, and is about to be built in this country in two or three instances of spans as great as the Menai tubes. I have lying upon the table before me a *new* edition of this work of Mr. Whipple, brought up to date, and is twice as bulky as the original volume. Through some peculiar idiosyncracy, the venerable author turned printer for the occasion, setting up the types with his own hands. It is in two parts, the first as it originally stood, the second an extension of the principles laid down in the first, together with explanatory notes, and a discussion upon counterbracing. There is also added a review and comparative analysis of the Fink, Bollman, Post and Whipple Bridges, which at this time becomes of peculiar interest, and I have no doubt this fact alone will cause much inquiry for this the best work extant on Bridge Building. To those interested it may be of service to know, that like the former edition the author keeps the present one in his own hands, and is not so careful to retain it as he used to be. There have been numerous inquiries for the first essays of Mr. Whipple, and his many known and unknown friends can now have the pleasure of testifying their appreciation of his labors. As the pioneer and teacher of Iron Bridge Building, Mr. Whipple will ever be regarded with gratitude by the profession at large, to say nothing of a deeper feeling to those who know him.

The address of the President, the Hon. Wm. J. McAlpine showed his warm sympathy and active exertion in furthering the interests of the Society, and he appealed to all present to keep up the spirit of association, and exert themselves to gather into the engineering fold all worthy members of a noble profession. The importance of such a Society as this can hardly be over-estimated, not only in the benefits reacting upon the members, but also the indirect effect upon the public at large. It is not a New York Society, but an American one in the truest sense, having members scattered over the whole of this broad country—who reap their benefits in the publications issued, which are carefully selected for their practical value. It is pleasing for a professional man, go where he will, to always find some one whom he can greet as a fellow in the same bond, who have interests in common and who feel that they are laboring toward no unselfish end, in using their best efforts for the elevation of the engineering profession.

One of these days, should the aspirations of the Society be fulfilled, they will have a building of their own, where will be found all matters of value to the engineer, and which will be, in fact, a repository of American engineering. 'Tis true, this climax is a long way off, but it is among the things that can be, should the profession cluster around the Society, as they ought to do, and it has a right to ask that they should.

Turning from such a prolific theme, to matters of more local interest, it may be interesting to note, that the long talked of East River Bridge will soon be under way, the contract having been awarded to a heavy Brooklyn firm. An eternity of boards have "sat upon" the project, and after weeks of incubation, have concluded Mr. Roebling knows what he is about, and accorded their gracious approval. The greatest interest will, of course, attach to the foundations, the engineer being prepared to go, if necessary, 100 feet below low water. The elevated railway drags its weary length along, the columns being all up as far as Thirteenth Street, the terminus of the Hudson River road. They seem still to be experimenting, but expect to have the line open by the fall. The joint interest of the Hudson River, New Haven and Harlem Railroads propose the erection of an enormous Union Depot at Forty-second Street and Fourth Avenue, which will probably be commenced in the fall.

A. P. B.



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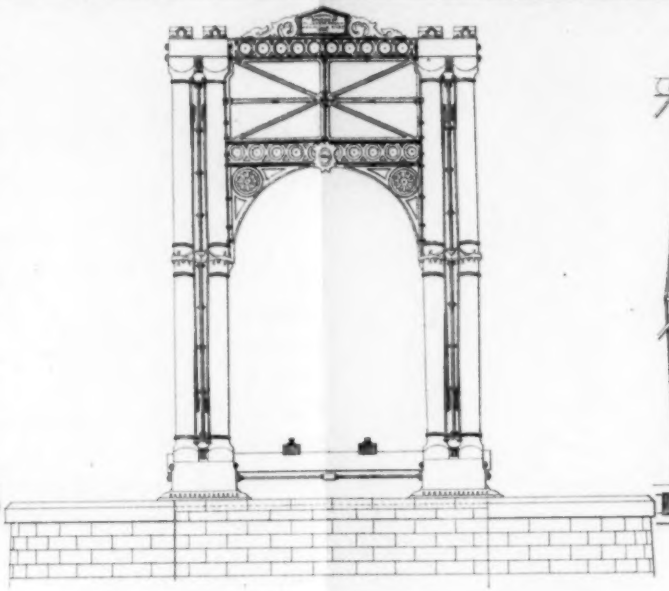
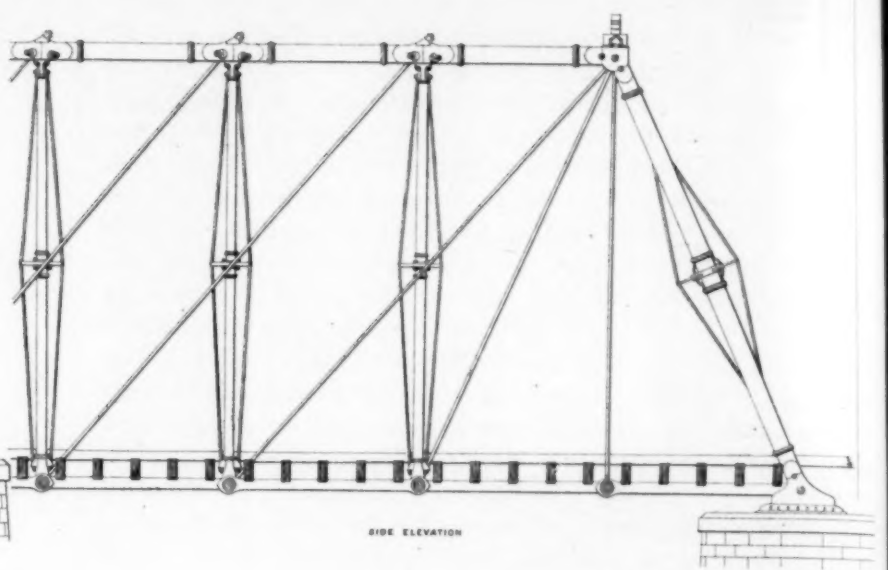


END VIEW

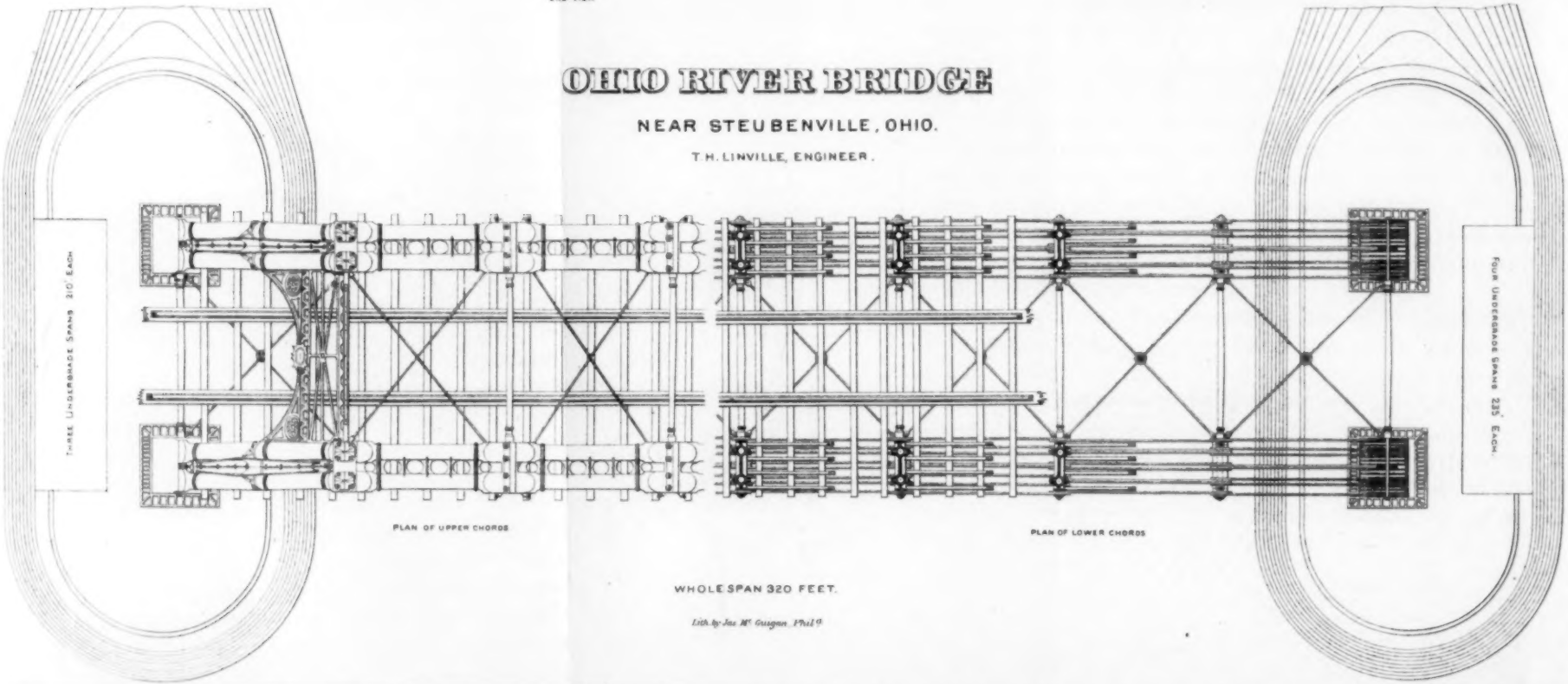


SIDE ELEVATION

OHIO RIVER BRIDGE

NEAR STEUBENVILLE, OHIO.

T. H. LINVILLE, ENGINEER.



PLAN OF UPPER CHORDS

PLAN OF LOWER CHORDS

WHOLE SPAN 320 FEET.

Lith. by Jas. Mc. Gregor. Phil.a

Civil and Mechanical Engineering.

OHIO RIVER BRIDGE AT STEUBENVILLE.

By J. H. Linville, Engineer.

A portion of the masonry for a bridge to connect the Pittsburgh and Steubenville Railroad with the Steubenville and Indiana Railroad, was erected in 1856, when the work was suspended. In 1862, the Western Transportation Company having arranged to complete the Pittsburgh and Steubenville Railroad to Steubenville, a lease of the franchises of the Holiday's Cove Railroad Company, with authority to erect the bridge over the Ohio River, was effected, and the work was executed under the auspices of the Trustees.

To the writer was assigned the duty of designing and superintending the erection of the iron superstructure.

By a revised location of some of the piers, the spans were reduced to four equal spans of 235 feet each, on the eastern side, between centres of piers, and three equal spans of 210 feet between centres of piers on the western side of the channel. The piers for the channel span are 90 feet in height above low water. They are 16 feet at the top, with a batter of 1 in 24. The adjacent undergrade spans are supported in a recessed chamber, four feet deep, in the sides of the piers, leaving an available thickness of 12 feet of masonry to support the channel span. The distance between the centres of these bearings is 320 feet.

An act of Congress required the channel span to be constructed so as to afford a clear opening of 300 feet between the piers and a clear height of 90 feet above low water.

These requirements rendered it necessary to support the track of the channel span on the lower chords; an arrangement which impairs in some measure the beauty and symmetry of the entire structure.

The bridge company desiring the completion of the structure in 1863, without in any manner obstructing the channel, no system of wrought iron construction then in use appeared available.

A selection had consequently to be made from the plans of composite structures in use, none of which had been extended to spans

of so great extent. The "Linville and Piper" patent truss was modified to meet the requirements of this particular locality, and adopted by the bridge company.

The description will be limited to an explanation of the peculiarities in the construction of the span over the channel.

The trusses are divided into 24 equal subdivisions 12 feet 3 ins. each, with two end panels 12 feet $6\frac{3}{8}$ ins., making the entire length from centre to centre of bearings 319 feet $0\frac{3}{4}$ in.

The height from centre of the lower chord to the top of the upper chord, at extremities is 28 feet, the upper chord having a camber of 9 inches, the posts radiating so as to render their bearing surfaces normal to the curve of the upper chord.

The lower chords consist of 8 lines of "Linville and Piper" patent upset eye bars, graduated in section to resist the maximum effects of the dead load, and of an uniformly distributed travelling load of 3000 pounds per lineal foot of superstructure, together with the transverse strain from the floor timbers, without producing a tensile strain in these bars, exceeding 10,000 pounds per square inch of sectional area.

The lower chords and the looped ends of the suspension diagonals are combined by means of connecting pins $4\frac{1}{2}$ inches in diameter, the suspension diagonals being so disposed between the chord bars and ribs on the bases of the posts as to produce a shearing strain only in the connecting pin.

The upper chords consist of two similar tubes of cast iron, having an external diameter of 15 inches at centre of each section, and slightly tapering towards the ends. These two sections are combined by intermediate cast iron ribs and webs, and terminate at the abutting surfaces in two double rectangular tubes with vertical ribs, between which pass the suspension bars.

By combining these tubes, greater width of abutting surface and consequently greater lateral stiffness was obtained. Under a maximum load the strain per square inch on upper chords does not exceed 10,000 pounds. The posts are also twin tubes of cast iron, 8 inches in diameter, combined by intermediate webs and ribs, and made in two sections, with flanged ends, through which and the intermediate parting plate, pass 16 bolts $1\frac{1}{4}$ inches to 1 inch diameter, securely combining the two sections of the posts to the parting plates and to each other. The parting plate has four projecting pieces, with concave bearings, to receive the truss rods, which are

secured near the top of the posts, and deflecting eighteen inches, bear against the parting plate at the centre of the posts, and passing through shoulders near the bases of the posts, are adjustable by screws and nuts at their lower extremity. The posts are graduated in thickness by Hodgkinson's formulæ, the factor of safety being assumed at one-eighth of the breaking weight. The suspension diagonals consist of four square bars, varying in section in proportion to the strains, and were rolled in one piece, without welds. The lower ends have loops or eyes, $4\frac{1}{2}$ inches in diameter, which receive the connecting pins.

At the upper ends, the section of the bar is circular, formed by upsetting the iron in moulds, under immense pressure, and then swaging the ends. Screws are then cut, the available section of the bar at this point, after deducting screw-threads, being equal to the sectional area of the square bar. The upper and lower lateral rods are graduated in size, decreasing from $1\frac{5}{8}$ inches diameter at the extremities of the span, to $1\frac{1}{8}$ inches diameter at the centre. The lower lateral rods have welded loops passing through eyes in the wide eye plates, secured on the ends of the connecting pins. They meet in a ring at their intersection, and are adjustable by screws and nuts. The upper lateral rods pass through the cast iron chords, and are adjustable by nuts bearing against angle bosses cast on the chords. A system of diagonals is also introduced between the posts and upper chords, the strut being placed at sufficient height to clear the traffic.

Heavy cellular pier plates of cast iron are interposed between the bases of the end columns and the masonry.

At one end provision is made for variations in length arising from changes in temperature by means of a series of rollers secured in a frame of wrought iron. The track is supported on longitudinal timbers of white oak, resting on the transverse white pine floor timbers, which are sustained by the wide thin eye bars that constitute the lower flange or chord. In consequence of the heavy Government contracts incident to the late civil war, and the scarcity of skilled labor, great delay was experienced in procuring the requisite materials; and the progress of the work was frequently interrupted. The erection of the shorter spans was begun in 1863. The channel span not being completed ready for erection during the stage of low water in 1864, its erection was deferred until the summer of 1865. To keep the channel open, and avoid risks from sum-

mer freshets, a wooden pier and two trestle abutments 40 feet in height, were erected to support two spans of wooden Howe truss bridge, on which were placed wooden trestles 25 feet in height, to carry the iron superstructure of the channel span. The erection of the channel span occupied about three weeks. The entire work was completed in August, 1865, without accident.

The general design of the deck spans is similar to that of the channel span. The end posts are vertical. The upper chords consist of cast iron tubes to resist the compressive strains, with two lines of rolled I beams, one at each side of each tube, to sustain the floor timbers supporting the track.

The channel span was fitted in the shops of the Pennsylvania Railroad Company, Altoona.

The Keystone Bridge Company of Pittsburgh were the contractors for the manufacture and erection of the seven deck spans, and the erection of the channel span; also, at the same time, for the manufacture and erection of the great double track iron span of 265 feet over the Monongahela River at Pittsburgh, the long line of plate bridge in South Pittsburgh, and the iron bridge at Saw Mill Run, all for the same line of road. The channel span over the Monongahela was constructed from the patterns of the channel span at Steubenville, such modifications being made as were necessary to adapt the bridge for a double line of rails.

All these bridges have been constructed by the aid of the most approved machinery; the bearings being actually planned and the eyes in the eye bars of chords being drilled with so great accuracy that no variation exceeding 100th part of an inch was allowed. To test the strength of the large tubes, and the wrought iron bars, chords, &c., a hydrostatic testing machine was provided, capable of exerting a compressive force of 675 tons on columns 3 feet diameter and 30 feet in length, and a tensile strain of 130 tons on bars 40 feet in length, or on any intermediate size; thus enabling the engineer to test to the proof strain, all the materials used in these structures.

Owing to unavoidable delays in the preparation of this machine, it was possible to test only a few of the posts, chords, bars, &c., but the results demonstrated conclusively the accuracy of the data from which the proportions of the tubes had been determined.

The completed structure was tested by passing a train of engines and cars loaded to their utmost capacity with railway bars, the load

entirely covering the channel span, and amounting to about 1¼ tons per lineal foot. The deflection being carefully indicated by a pencil point on a rod fixed to the scaffolding, free from the structure, did not exceed five-eighths of an inch. The weight of cast iron in the channel span is greatly increased by the material consumed in the webs and ribs combining the twin chord tubes and posts, also in the additional system of transverse struts to resist the effects of the diagonal bracing. By combining the posts and chords in this manner, the effective width of each truss was increased to 45 inches, thus adding to the lateral stiffness of the posts and chords, and ensuring the lateral stability of the bridge. This system of combining and trussing the posts was new and untried. This span was the pioneer of long spans of iron truss bridges on this continent, and to ensure success it was deemed prudent to allow considerable margin on the side of safety.

The weight of cast iron consumed in the construction of the channel span was 2136 pounds per lineal foot, and of best refined wrought iron 1423 pounds per lineal foot.

The line was opened in September, 1865, and since that time the bridge has sustained the constant heavy traffic without developing any defects, or requiring adjustment.

Since the completion of this bridge, arrangements have been effected with the "Union Iron Mills" of Pittsburgh, to furnish the "Linville and Piper" patent wrought iron tubular columns, "Upset Chord Bars," and wrought iron beams for the patent upper chords, which are now generally adopted in the construction of long spans. They would have been employed in the Ohio River Bridge in preference to cast iron upper chords and columns, if delays in the preparation required to manufacture these shapes had not been apprehended.

Self-Registering Compass.—An instrument of this description, devised by Captain Albini, of the Italian Navy, and constructed by Messrs. Elliot Bros., of London, was exhibited at the late Conversazione of the Institute of Civil Engineers. It consists essentially of a compass, with a card carrying types at its periphery in such a way that, by an attached clockwork, an impression may be made at stated intervals on a band of paper, from whatever type is over a certain point at these times. Thus clearly an almost continuous record of the ship's course may be automatically produced.

STEAM BOILER EXPLOSIONS.

THERE it no subject upon which we have written more than that of steam boiler explosions. These occurrences are denominated "accidents," but long past experience has taught us that they almost invariably owe their origin to either faulty construction, bad working, or careless and inefficient tending. "Accident" is the convenient term under which steam users often obtain absolution from culpable carelessness, or even wilful and criminal neglect. As matters stand at present, boiler makers can palm off bad boilers on the public, and steam users employ them with the certainty that when they explode with fatal consequences they will, by the help of a coroner and his jury, be publicly absolved from all responsibility, and the event proclaimed to be "accidental." We have said frequently before, and we again repeat, that the causes of explosion are so simple, their results so fatal, and their occurrence so frequent, that it is high time some action was taken to secure common sense investigations into these matters. The Manchester Steam Users' Association has done very much, through their engineer, Mr. L. E. Fletcher, in exposing the fallacy of the present system of investigation. At the last annual general meeting of its members, as well as at the previous one, attention was called to the unsatisfactory character of the inquiries conducted by coroners with regard to fatal boiler explosions, and to the erroneous verdicts returned. It was also shown how important it was that this evil should be corrected, and sound information disseminated in every case, in order to check the loss of life and suffering at present recurring week by week, and at the same time render unnecessary any governmental action, which might prove an interference with the freedom of the steam user. With this view, resolutions were passed at both of those meetings, requesting the committe to take the necessary steps to secure these investigations being rendered more satisfactory, so that the truth might be fully arrived at and plainly spoken in every case. In order to place the matter prominently before the public, a paper upon the subject was read at the last meeting of the British Association. Following this, at the annual general meeting of the Steam Users' Association, held on March 9 last, it was proposed that the attention of the Government should now be drawn to the subject, and that a deputation should wait upon the Home Secretary with a memorial.

Thus far, this useful association had proposed. Now came the time to act; and we find that no time was lost in carrying out the proposition. At the following meeting of the Executive Committee, a memorial was submitted for approval, discussed and adopted. Mr. Thomas Bazley, M.P. for Manchester was at once communicated with, and his assistance in the matter requested; and through his good offices, a deputation of the Association had an interview with Mr. Bruce, the Secretary of State for the Home Department, on Friday, April 16. A sudden and severe attack of illness prevented Mr. Fairbairn, the President of the Association, accompanying the deputation. It consisted of three of the Vice-Presidents, Mr. Thomas Bazley, M.P., Manchester; Mr. Hugh Mason, Ashton-under-Lyne; and Mr. John Penn, C.E., Greenwich. Also of Mr. John Lancaster, M.P., Wigan; and Mr. Thomas Schofield, Manchester, members of the Executive Committee; as well as of Mr. John Hick, M.P., of Bolton, Corresponding Member, and Mr. L. E. Fletcher, Chief Engineer. Mr. Bazley introduced the deputation to the Home Secretary, and briefly called attention to the serious loss of life and suffering entailed by steam boiler explosions. He pointed out that this was preventable, and explained that it was the wish of the memorialists that coroners should be empowered and instructed to command the attendance of eminent engineers to give evidence, when conducting enquiries, in consequence of these sad disasters, so that the light might be thrown on the subject, and greater care induced; by which means, it was thought that the loss of life and property now occurring would be much lessened, if not altogether prevented. Mr. Bazley concluded by presenting Mr. Bruce with the memorial, which we shall now proceed to notice.

We have often had occasion to observe that it is entirely in the hands of steam users whether they will, by the exercise of common sense and ordinary discretion, save themselves from Government interference and control, or whether, by persistently pursuing a short-sighted and danger-fraught policy, they will continue to court that supervision which they would be the first to most strenuously resist. Nor would we wish to see such a system established. Nor does the Steam Users' Association desire this. On the contrary, the object the memorialists have in view is not to promote a system of Governmental periodical boiler inspection, to which manufacturers entertain a strong feeling of repugnance, and which the

Association was originally founded to prevent. But the object is to so improve coroners' inquiries with regard to boiler explosions, that sound views with regard to the causes of these disasters may be disseminated, and all mystery with regard to them dispelled. Boiler explosions would be prevented, and further Governmental interference would be rendered unnecessary, if only faithful investigation and plain speaking were made compulsory. And the way in which this is to be accomplished is clearly set forth in the memorial. That important document first points out the constant loss of life and the suffering arising from steam boiler explosions. At the present time, nearly fifty explosions occur on an average every year, killing from sixty to seventy persons, and injuring as many others. Many of the persons killed and injured are bread-winners, so that not only do they suffer, but a great many others are rendered more or less destitute. The number of persons killed every year by boiler explosions exceeds the number of passengers killed on all the railways throughout the United Kingdom. From the return published by the Board of Trade, it appears that during the last six years, 123 passengers were killed, while during the same period 390 persons were killed by boiler explosions, the annual average of lives lost being from twenty to twenty-one in the case of railway passengers, and of sixty-five in consequence of boiler explosions. Thus it will be seen that for every passenger who loses his life by railway travelling, three persons are killed by boiler explosions.

Such are the results. Now as to the cause; and this, as shown by the memorial, is summed up in one short word—neglect. The system of voluntary periodical boiler inspection carried out by the Association for the last fourteen years has proved fully adequate to the prevention of explosions; not a single boiler ever guaranteed has exploded. The constant investigations of boiler explosions have shown that much unnecessary mystery has been attached to the subject of steam boiler explosions, and that they all arise from the simplest causes, and could readily be prevented. As a rule, boilers burst simply because they are bad. Bad either from original malconstruction, or bad from the effects of hard work and old age. In a word, the cause of every boiler explosion is neglect, and the preventive simply care. It would follow that if people will have no care for themselves, no one ought to care for them. But the suffering does not always fall on the careless ones. Death is

dealt around amongst the innocent, whilst the guilty are generally absolved, even from blame. It is for and on behalf of the real sufferers that the Association interferes, and by the memorial shows coroners' investigations, with regard to steam boiler explosions, to be incomplete, and the verdicts delusive. It is not as an institution that the coroner's inquest is condemned, but it is the manner in which it is practically carried out to which the strictures in the memorial refer. The next point is, how this difficulty is to be met.

The plan recommended for adoption in the memorial is simply that every coroner should be both empowered and instructed, when conducting an inquiry consequent on a fatal steam boiler explosion, to avail himself of the assistance of two competent engineers, having no connection with the works at which the explosion occurred. These engineers are to visit the scene of the catastrophe, investigate the cause of the explosion, and report to the coroner thereon, their reports—which may be either joint or several, as most convenient—to be accompanied with explanatory sealed drawings, showing the original construction of the boiler, and, as far as possible the lines of rent, as well as the direction in which the fragments were thrown, and the distances at which they fell. The engineers to attend the inquest, and assist the coroner in his examination of witnesses, as well as to give evidence themselves before the jury. Further, in order to secure to the public the full advantage of the investigation, the engineers' reports, with the drawings, to be printed and deposited in the Patent Office, and to lie there for inspection and purchase, as in the case of specifications of inventions. Also copies of these reports to be forwarded to the members of both Houses of Parliament, as in the case of reports on railway accidents.

Such a course of procedure would primarily result in the accumulation of a mass of very valuable information. But beyond this—and what is of the highest importance—the responsibility of every steam boiler explosion would be brought home to the right party. This would render any further Governmental action unnecessary, and very shortly put an end to steam boiler explosions, simply by the force of truthful investigation and plain speaking. The fact is not lost sight of that many coroners have already the power—of which, in some cases, they avail themselves—of remunerating competent scientific witnesses, and which proves of considerable public service. But such is not the case in every instance, and coroners

to whom the plan proposed in the memorial has been mentioned, have stated that it would prove of considerable assistance to them in conducting their investigations on such technical subjects as boiler explosions, and that they should be glad to see it brought into operation.

In his reply to the memorial, Mr. Bruce appeared to fear that there might be some partiality in affording to boiler attendants a Governmental investigation on the occurrence of fatal disasters, without extending that protection to railway passengers and colliery workers. But it should be remembered that the very protection now sought for boiler attendants is already enjoyed by railway passengers and colliery workers, while the boiler attendant is left unbefriended, so that the partiality anticipated already exists to the neglect of the poor stoker, while the tendency of the Association's proposition would be, not to create a partiality, but to remove one already existing. The plan recommended is, in fact, simply an extension to boiler attendants of the privileges enjoyed by railway passengers and colliery workers, though in a slightly different form. In the event of a railway disaster, a Government engineer is sent down to make an investigation, and report to the Board of Trade thereon, his report being presented to the members of both Houses of Parliament, and open to the purchase of the public; while, in addition, he attends the coroners' inquest, and assists in the examination of witnesses. In the event of a colliery explosion, a Government mining inspector is present at the inquest, and assists the coroner in conducting his inquiry; while an annual return of colliery explosions is published. In the event, however, of a boiler explosion, though the subject is one of a technical character, and on which a good deal of misapprehension exists, while questions arise with regard to it which may fairly be considered as beyond the province of what is technically termed "common knowledge;" yet boiler attendants are left without the protection of a satisfactory investigation of the cause of the catastrophe, and evidence from incompetent parties, or from those interested in suppressing the facts, is accepted, and, consequently, as so often stated, the truth is seldom arrived at and seldom spoken.

It will be seen, from what we have stated, that some action is needed to redress the present inequality, and afford to boiler attendants the privilege of as unbiassed an investigation as is now secured by the Crown to colliery workers and railway passengers. The

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initial movement in this action is now being taken by the Manchester Steam Users' Association, and should they succeed in bringing the measure they propose into operation, they will richly deserve the thanks of boiler attendants, boiler owners, and boiler makers. They will deserve the thanks of boiler attendants for saving the lives of some sixty or seventy of their number every year, many of whom are bread-winners, and by thus preventing a vast amount of suffering, not of themselves only, but also of their families. They will deserve the thanks of boiler owners and boiler makers for preserving them from a system of Governmental periodical inspection, to which sooner or later they would otherwise inevitably subject themselves, and which could not fail to be harrassing, and to limit progress. They will also deserve the thanks of the public for the additional security they will have imparted to life and property. We give them our cordial support in the matter, and our best wishes for their success.—*Mechanics' Magazine.*

ON THE BRIDGE OVER THE THAMES CARRYING THE WEST LONDON EXTENSION RAILWAY.*

By Mr. Lawford, M. Inst. C. E.

This bridge was erected for the purpose of carrying the West London Extension Railway (which connects the North-Western and Great-Western Railways with Victoria Station, at Pimlico), across the River Thames, between Chelsea and Battersea, under the provisions of an Act of Parliament, which received the royal assent on August 13, 1859. The bridge consists of five segmental arches of wrought iron, each arch having a span 144 feet on the skew, with a rise of 16 feet, or $\frac{1}{9}$th of the span. There are also, on the Middlesex side of the river, six, and on the Surrey side four, land arches of brick work, each with a span of 40 feet and a rise of 10 feet. The total length, therefore, of the whole structure is 1,270 feet. The abutments and piers of the five main openings are massive pieces of masonry, and are carried to a depth of 36 feet below Trinity high water mark, and 14 feet below the bed of the deepest part of the river. The soffit of the arches at the crown is 22 feet above the same point, *i. e.*, Trinity high-water mark, in accordance

* Abstract of paper read before the Civil and Mechanical Engineers' Society.

with the requirements of the Admiralty and the Conservators of the River Thames. The level of the rails is 26 feet above Trinity high-water mark. The width of the river between the two abutments is 776 feet on the skew, and 706 feet on the square. The width of waterway afforded is 720 feet. The angle at which the bridge crosses the river is 75 degrees. The greatest depth of water is 22 feet below Trinity high-water mark, the average rise and fall of the tides at this place being about 13 feet 6 inches.

The piers were constructed in coffer-dams, the inner row of piles being 5 feet from the outer edge of the lowest course of masonry, and were driven to a depth of 15 feet below the bed of the river; the outer row were 5 feet from the inner row, and were driven to a depth of only 8 feet from the same point, the space between the two rows of piles being filled with puddled clay. At the conclusion of the work the outer row of piles were drawn, but the inner row of piles were cut off level with the bed of the river. As the masonry of the piers proceeded, the space between them and the piles was filled with puddled clay, well trodden in, to a height of 3 feet above the bed of the river. Each pier stands on a bed of concrete 2 feet thick, extending 3 feet beyond the lowest course of footings. On the concrete is laid a course of York landings, 1 foot thick, and projecting 1 foot beyond the footings.

The foundations are carried up in a brick work to within 2 feet of the bed of the river, where there is a through course of stone 2 feet thick. From this point to the springing of the arch, the pier is faced with picked face ashlar of Bramley Fall stone. There is a second through course of stone half way between the bed of the river and the springing, and the upper, or last 7 feet of the piers, including the springers (which are 3 feet thick), are entirely solid stonework. The two abutments are built similarly to the piers, except that they have hollow chambers, filled with gravel to a height of 3 feet above the springing of the arch; each abutment being just on the edge of the river required only half a coffer dam for its construction. All stone work of both piers and abutments above springing height is tool dressed. The concrete used in this bridge was composed of five parts of gravel to one of blue lias lime, and the mortar of two measures of sharp sand to one of the same sort of lime.

Each of the river arches is composed of six wrought iron ribs, arranged in pairs, 2 feet 6 inches apart from centre to centre. The

arch or voussoir of the four main or inside girders is formed of $\frac{3}{8}$ inch vertical plates, 39 inches deep at the springing, and 24 inches deep at the crown, with double angle irons, each 4 inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch top and bottom, to which the flanges are attached by means of rivets. There is also a packing strip 8 inches by $\frac{1}{2}$ inch between the angle iron and the flanges. The flanges consist of two $\frac{5}{8}$ inch plates, 18 inches wide. The upper member of the inside ribs is a horizontal parallel girder, similarly constructed, but only 24 inches deep throughout its entire length. The vertical web is $\frac{1}{4}$ inch plate from the pier to the point where the upper and lower member intersect, *i. e.*, 15 feet from the centre of the arch, and from this point both vertical webs are $\frac{3}{8}$ inch in thickness. The bottom flange of the horizontal girder consists of one plate $16\frac{1}{2}$ inches wide by $\frac{1}{2}$ inch, two angle irons $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and a packing strip 8 inches by $\frac{1}{2}$ inch. The upper flange is 15 inches wide, all other dimensions being the same as those of the lower flange; but the top plate is slightly curved inwards towards the rails. In the two outside ribs the voussoir is constructed as already described, but is 30 inches deep at the crown, and 39 inches at the springing. It may be as well to mention here that in these two girders, on the outside faces of the arch, all the rivets, excepting those in the angle irons, are countersunk, no cover plate either being visible at the joints. The whole centre web presents, therefore, the appearance of one smooth unbroken plate. This centre web is a $\frac{3}{8}$ inch plate, the two flanges are single $\frac{1}{2}$ inch plates 16 inches wide, the angle irons $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{1}{2}$ inch, and the packing pieces 8 inches by $\frac{1}{2}$ inch. The upper member is constructed in the same manner as that of the inside rib, but it has throughout the whole span $\frac{1}{4}$ inch vertical plates, and is only 18 inches deep at the crown of the arch. The upper flange is 18 inches wide, and is parallel with the lower flange, which is only 15 inches wide. The angle irons and packing pieces are of the same dimensions as those already described for the inside top members. The total depth of the girders, both inside and outside at the centre of the arch, is the same, viz., 48 inches.

The sectional area of each of the four main girders is as follows: In the arch at the springing, 80 square inches; in the upper member do., 43 square inches—total, 123 square inches; and at the centre of the arch, where the upper and lower members are together, 105 square inches, the mean average being 114 square inches. These

are the full sectional areas, including the rivets. The voussoir and the upper horizontal girder of the four main girders are connected together by a lattice spandrel, composed of H-iron, of three different sizes, viz., 7 inch, 6 inch and 5 inch by ½ inch. A stiffening bar of flat iron, ⅜ inch thick, is added to each side of the H-iron, connecting the lattice bars throughout at the angles of intersection. In the outside girders the lattice and stiffening bars are all made of double T-iron, riveted together, thus $\frac{I}{I}$, and of the same dimensions as the H-iron, *i. e.*, 7 inches by 3½ inches, 6 inches by 3 inches, and 5 inches by 2½ inches, all ½ inch iron. Each pair of ribs is connected near the haunches by means of frames, composed of angle irons, cross braced and riveted to the ribs, forming an open box girder. This principle is continued to the crown of the arch, where the voussoir and top girder unite in a double cell. Each pair of main girders are braced together at the haunches by means of trellis transverse girders 2 feet 6 inches deep, carried up at equidistant intervals to within 10 feet of the centre of the arch. There are seven of these in each half arch; they are composed of angle and bar iron, 3½ inches by 3½ inches by ½ inch. The top members of the main ribs are secured together by the cross girders, which carry the roadway; the are fixed over the whole length of the bridge, 4 feet apart from centre to centre, and are composed of a middle web of iron, 10 inches deep, and ½ inch thick, the bottom of which is flanged with double angle iron, 3½ inches by 3½ inches by ½ inch, and the top with double channel iron, on the lower flange of which the buckle plate flooring rests. The cross girders rest on the lower flange of top main girder, and are secured in their places by iron knee-pieces, riveted through the centre webs. The main or bearing girders are again cross braced by diagonal rods, bolted to a centre plate, and to brackets riveted on to each of the angles. There are three sets of these tie-rods in each half arch.

Upon the end of each arch or voussoir a plate of cast iron, 3 inches thick is fixed, the back of which is planed quite true and even. These, again, fit into heavy cast iron shoes (weighing 2 tons each), let into the stone skewbacks of the piers and abutments, and by means of wrought iron wedges are finally adjusted in their seats. Contraction and expansion are provided for as follows: Cast iron standards are bolted to the stone work of the piers and united by a cast iron frame, secured with bolts and nuts. These standards have

recesses to receive the ends of the horizontal girders, and secure them in position, at the same time allow for horizontal motion. A bed and bearing plate, planed perfectly parallel, are fixed under the ends of the horizontal girders, upon which they slide.

The railway is a double line of mixed gauge, and is carried over the bridge by means of longitudinal timbers with transoms every 10 feet. Ash ballast is used all over the bridge. A cast iron moulding is attached to the horizontal girder, throughout its whole length, and a cast iron plinth is bolted on to the top of the same; an ornamental cast iron parapet is fixed on the plinth, and the whole is surrounded by a wooden hand rail. The iron of which this bridge is built was manufactured by the Shelton Iron Company, at Stoke-upon-Trent, and is, perhaps, better known as Lord Granville's iron. In the experiments made for testing the quality of the iron, it bore a tensile strain of nearly 18 tons per square inch, without showing any signs of fracture. The H and T-iron used in the spandrils was rolled by the Butterley Iron Company. About three-quarters of the iron work was made and put together by Messrs. Calvert, of York, and, on the collapse of that firm, it was completed by Mr. Charles Lungley, the iron ship builder of Deptford. The contractor for the work, and, indeed, for the whole of the West London Extension Railway, were Messrs. Brassey and Ogilvie—names well known in the railway world—and a sufficient guarantee that the work would be well and substantially carried out. The width of the bridge between the cast iron parapets is 30 feet in the clear. The total width of the piers from out to out above springing level is 35 feet 6 inches, and at that level, including the cut waters, 53 feet 6 inches. The total cost of the bridge was £104,000, or £82 per lineal foot, and £2 10s. per superficial foot. The materials used in its construction were 2,000 cubic yards of concrete, 11,100 cubic yards of brick work in mortar, 130,000 cubic feet of stone, 2,160 tons of wrought iron, 366 tons of cast iron, 2 tons of lead, and 28,000 cubic feet of timber, exclusive of the piles. This bridge was the joint design of Messrs. Baker and Bertram, the chief engineers of the Great Western and North-Western Railways. It was opened for public traffic on March 2, 1863, since which date some hundreds of trains have passed over it daily, and I am not aware that, up to the present time, any expense whatever (beyond the maintenance of the road) has been incurred, either in repairs or otherwise. The bridge was only 15 months under con-

struction, *i. e.*, from the time the first stone was laid until a locomotive passed over the river. The bridge was very severely tested on January 7, 1863, by Captain Tyler. The narrow gauge load consisted of two locomotives and tenders, funnel to funnel, and two tank engines; total length of train 132 feet, total weight 176 tons. The broad gauge load consisted of two tank engines, in the same position as the narrow gauge engines, each drawing six loaded coal wagons; total length of train 276 feet, total load 292 tons; these two loads, collectively, being equal to about 2¼ tons per lineal foot. First, the narrow gauge load passed over No. 1 arch at speed, the deflection 5-100ths of a foot. Second, the broad gauge load passed at speed—same result. Third, the broad gauge load on one road and narrow gauge on the other, both passed together over No. 2 arch at speed. On going over No. 1 arch, No. 2 rose 3-100ths of a foot. On going over No. 2 it deflected nearly 10-100ths of a foot, rise and fall 13-100ths of a foot. Fourth, both loads were brought to rest on No. 2 arch, deflection 11-100ths of a foot. When the loads passed slowly over No. 3 arch, No. 2 rose 2-100ths of a foot, rise and fall 13-100ths of a foot. Both loads remained stationary for some time on this arch, but no further deflection took place, and, with the removal of the load, the girders rose simultaneously to their original height. Fifth, the same thing was done on No. 3 arch with a precisely similar result. Sixth, the same experiment was made on the fourth arch, and in exactly the same manner as the fourth experiment—rise of arch 2-100ths of a foot, deflection 10-100ths of a foot, rise and fall 12-100ths of a foot. Seventh, the the same thing was done on the fifth arch; the rise was 2-100ths of a foot, deflection 8-100ths of a foot, rise and fall 10-100ths of a foot. The bridge was very steady throughout these experiments, and there was very little lateral vibration, even when both loads passed at the same time in the same direction, either slowly or at speed.

Hair Springs for Watches.—A striking instance of the immense value a small piece of steel may acquire by the great power of skilled mechanical labor, is the balance-spring of a watch. From its extreme fineness and delicacy, 4,000 weigh not more than one ounce, and exceed in value $5000.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 27.)

From a circular issued by P. V. H. Van Riper, of Paterson, N. J., we select the following:—

"Having been engaged in the manufacture of Oak Leather Belting for the past fifteen years, I would respectfully call attention to the essential points necessary to the manufacture of good belting, the first of which is the selection of the leather, which should be *oak tanned*, it being more pliable than any other, and as durability is required, it should be thoroughly tanned and made from young hides, they having more strength than the hides from old animals.

"Suitable leather having been chosen, though it may be ever so good, may be spoiled in currying, and as this is an important part, it is conducted under my own supervision, where I have the *shoulders* cut from the hides, and nothing but FOUR *feet in length of the choice butts*, curried for belting purposes, as the *shoulder naturally stretching in a different direction* from the butts, causes that great annoyance in factories of belts running crooked.

"The putting on of belts should be done by a person acquainted with the use of belting, and too much judgment cannot be exercised in this respect, as the wear of the belt depends considerably on the manner in which it is put on, therefore, the following suggestions, if practiced, will be of much service to persons employed in this capacity. The butts to be joined together, should be cut perfectly square with the belt, in order that one side of the band may not be drawn tighter than the other. For the joining of belts, good Lace Leather, if properly used, being soft and pliable, will always give better satisfaction than any patent fastening or hooks which have yet been invented.

"Where belts run vertically, they should always be drawn moderately tight, or the weight of the belt will not allow it to adhere closely to the lower pulley, but in all other cases they should be slack.

"In many instances, the tearing out of lace-holes, is often unjustly attributed to poor belting, when in reality, the fault lies in having a belt too short, and trying to force it together by lacing, and the

more the leather has been stretched while being manufactured, the more liable it is to be complained of.

"All leather belting should occasionally be greased with the following mixture, or it will become dry and will not adhere to the pulleys: one gallon neats foot or tanners' oil, one gallon tallow, twelve ounces resin, dissolved by heat, and well mixed together, to be used cold, the belt having been previously dampened with warm water, except where it is spliced together. During the winter season, an extra quantity of oil should be added to the mixture.

"To obtain the greatest amount of power from belts, *the pulleys should be covered with leather*, this will allow the belts to be run very *slack*, and give twenty-five per cent. more wear. I drive a large circular saw, requiring fifteen horse-power, with a very slack belt, the pulleys being *covered with leather.*

"For heavy counter belts not intended to be used on cone pulleys, or at half cross, I recommend double belts made from shoulders only, which I furnish at the price of single belting, and as the *stretch is taken out of the shoulders after they are cut from the side*, they are guaranteed to give better satisfaction as a counter belt, than a single belt will.

"More power can be obtained from using the grain side of a belt to the pulley than from the flesh side, as the belt adheres more closely to the pulley; but there is this about it, the belt will not last half so long, for when the grain, which is very thin, is worn off, the substance of the belt is gone, and it then quickly gives out; so that I would advise the more saving plan of obtaining power by driving with wider belts, and covering the pulleys with leather.

"Where belts are to run in very damp places, or exposed to the weather, I would recommend the use of rubber belting; but for ordinary use it will not give the satisfaction which is so generally obtained from using oak leather belting, as it cannot be run on cone pulleys through forks, or at half cross, and with fair usage would be worn out, while a leather belt was regularly performing the work allotted to it; for when the edge becomes worn, the belt soon gives out."

We formularize the following rules from the text:—

$$\text{H P} = \frac{3\,w\,c\,v}{16000}$$

$$\text{W} = \frac{16000\,\text{H P}}{3\,c\,v}$$

In which H P = number of horse-power transmitted.
w = width of belt in inches.
c = belt contact with smaller pulley in lineal feet.
v = velocity of belt in feet per minute.

The following examples are given: "A 13½-inch belt, running at the rate of 1600 feet per minute, over a 4 feet pulley, and touching 5 feet of its circumference, gives 20 horse-power." This is equal to 888·88 square feet of belt per minute, per horse-power.

"A 20-inch belt at 2000 feet per minute, on 6 feet of the circumference of a 4 foot pulley, gives 45 horse-power." This is equal to 74·074 square feet of belt per minute per horse-power.

From an article in *Appleton's American Cyclopedia*, we take the following:—

"Belts are used instead of gearing, when the shafts to be connected are far apart.

"Belts in general are used between parallel shafts, and when the direction of motion is desired to be reversed, the belt is crossed.

"The diameters of belt pulleys are in the inverse ratio of their speeds.

"To modify the velocity while in motion, conical drums are employed on parallel shafts, with the cones reversed in position, and a shifter used to move the belt and hold it in any desired position.

"When shafts are not parallel, but are in the same plane, the only way to connect them by belts, is to use a third shaft placed across both, and at equal angles, or nearly so, with each, and to which each is connected by a belt.

"When shafts are neither parallel nor in the same plane, they can be connected by a belt, but there is only one place on the shafts for the pulleys. These must be at the ends of a straight line perpendicular at the same time to both axes. There is only one such line. This theoretical place has to be corrected in each particular case, according to the diameters of the pulleys, by taking care that the belt arrives square on each pulley, no matter how obliquely it leaves the other.

"As a consequence of this unavoidable connection, the motion of the shafts cannot be reversed without securing the pulleys in other places.

"A careful attendant will make a belt last five years, which through neglect, might not last one.

"It has been found in practice, that belts must not be run faster

than 30 feet per second, nor have a tension of above 300 pounds per square inch of section.

"The friction of a belt is double on wood what it is on cast iron.

"If a belt is passed over a horizontal cylinder with a known weight suspended at one end, and a spring balance attached to the other, and gradually let go until the belt begins to slide, the suspended weight *minus* the weight indicated by the balance, is the friction.

"It has been found that by taking a turn and a half around a rough cylindrical post, 1 pound will hold 110 pounds in check, and that by taking 2½ turns, 1 pound will hold 2500 pounds.

"A 12 inch belt over a 4 feet pulley at 30 feet per second, will transmit the power of a 6-inch cylinder engine having 12-inch stroke, running 125 revolutions per minute, under 60 pounds of steam."

If we allow 30 pounds average pressure per square inch on piston, this engine will give 6·4 HP., and the data above, 281·25 square feet of belt per HP. per minute, which is a liberal allowance. See example No. 12, in first article.

"Where pulleys of very unequal diameter are coupled by a belt, the surface of contact with the smaller pulley is so little that the belt must be very tightly stretched in order to transmit its full duty. This is especially the case where the two pulleys are very near each other. In the case of the small centrifugal pumps, made by Gwynne & Co., for plantation and farm use, the horse gear is connected with the pump by belting from a large pulley to the riggers of the pump, the relative diameters of the two being about as 6:1, while also they are placed but four or five inches apart. The short belt, thus acting upon a very small portion of the surface of the rigger, requires to be very tightly stretched, and in this way a heavy strain is brought upon the bearings. To relieve this strain, Messrs. Gwynne & Co., place a friction wheel between the pulley and rigger, so as to touch both in a line connecting their centres. This wheel, revolving freely upon a fixed center, receives the strain exerted by the belt. No means of adjustment are provided to compensate for the wear of the journals, nor is such provision believed to be necessary. The arrangement, so simple in itself, appears to possess a considerable advantage over the ordinary practice of throwing the whole strain of the belt upon the bearings."

"The intermediate pulley is recessed in the centre of its face, so as to bear on the others at the edges only. The arrangement is said to work well, and is here shown.

"A leather belt, 19½ inches wide, is driven by a drum 11 feet in diameter, having iron arms and wooden lagging, and making 92 revolutions per minute; consequently, the belt moves at the rate of 3179 feet per minute. The amount of power transmitted by this belt is estimated at 175 horse-power, corresponding to a tension of the tight side of the belt of not less than $\frac{175 \times 33{,}000}{3179} = 1817$ pounds. The pulley driven by the belt is 6 feet in diameter, and is entirely of iron; the peripheries of both drum and pulley are covered with leather. The belt is made of two thicknesses of leather cemented together, and is about ⅜ inch thick; it was slightly greased on the inside with a mixture of tallow and neats-foot oil. The slack side running upwards nearly vertically."

The data above give 29·5 square feet of belt per minute, per horse-power, and a tension of 93·18 pounds per inch wide.

Rule for ascertaining the horse-power of belts, by Mr. F. W. Bacon, of New York, from *Sci. Am.*, July 17, 1869, p. 35. We convert the text into the following:—

$$\frac{\text{H P } 6000}{v\,c} = w.$$

In which H P = horse-power transmitted.
v = velocity of belt in feet per minute.
c = contact of belt with smaller pulley in lineal feet.
w = width of belt in inches.

PUMPING ENGINES.

By H. P. M. Birkinbine, C. E.

The article on "Pumping Engines," in the May number of the *Journal*, page 323, has been replied to by one of the makers of the direct-acting duplex short-stroke pumping engine, in a letter published in the June number of the *Journal*, page 425.

It was not necessary for any one to personally apply the remarks in the closing paragraph; they were general, and their truth cannot be denied. The complaint that the "spirit of the article" is "detractive and unjust," and the presentation of a table, arranged to suit the purpose, is no answer to the article. Little importance can be attached to tables, certificates and statements when prepared and presented by interested parties. It would have been far more satisfactory and useful, if some one of those interested in this form of pumping engine, would reply to that portion of the article which "deals with the principles upon which the engine is constructed," instead of complaining of the "spirit." It is *pumps*, not *persons*, which are to be discussed.

The article has certainly had one good effect. It has reduced the duty claimed for these pumping engines from 1,300,000 foot-pounds to 473,328 foot-pounds,—from the regions of impossibility, to those of possibility.

From a personal observation of several of these engines, and a careful analysis of the working, for the past two years, of a large one furnishing water to a city, I am satisfied that the duty given in the article, (200,000 foot-pounds) is large and ample.

It is to be hoped that the "unjust" statements in the article will be exposed, and the means given by which the extraordinary results claimed for this form of engine are produced. Until such information is imparted, the public cannot be expected to accept any mere statements of duty, however wonderful they may appear.

In physics, supernatural means are never estimated, but some arrangement is looked for in accordance with well known laws, to produce results.

When a machine is defective in its proportions or arrangements, low results are the consequence. As the pumping engine is the machine by which the power of the steam of the boiler is applied to force the water, any defect in its arrangement or proportions will result in a waste of steam, and, necessarily, of fuel, and, as a consequence, the duty will be low, whoever the maker may be, or by what name it may be called, or how many patents may be concentrated upon it. If the duplex direct-acting short-stroke engines are thus defective, as I endeavored in my former article to show, then the low duties are inevitable.

A Cornish engine is now running which produces a lower duty than a double-acting high-pressure fly-wheel engine used in the

same works illustrating defects in construction. The cost of fuel used by the different engines pumping water for supplying London, varies from .075 pence to ·543 pence per million foot-pounds.

As the engines for which these extraordinary high duties are claimed are covered by one or more patents, there is no necessity for secrecy. By no other means can they so readily be brought into notice as by a thorough and candid discussion of their peculiarities.

A SYPHON FOR DRAINING A TUNNEL.

By Col. Claudius Crozet, C. E.

Mr. Editor:—I hand you this paper for insertion in your *Journal* if you consider it of sufficient interest. It was given to me many years ago by my friend the late Col. Crozet himself. The Colonel had at one time held the distinguished position of superintendent of the U. S. Military Academy at West Point; and subsequently was Chief Engineer of the work alluded to in the paper.

Yours respectfully,

John C. Trautwine.

The tunnel through the Blue Ridge, in Virginia, is 4,273 feet long, and 700 feet below the top of the mountain; on this account it was thought expedient to construct without shafts. This tunnel slopes from west to east, at the rate of 70 feet to the mile, so that, on the west side, the water, which proved very abundant and troublesome, had to be removed by artificial means. For some distance at the entrance, I determined to introduce a syphon of unusual length, which proved a difficult and, at the same time, interesting experiment.

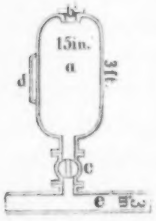
The whole length of the syphon is 1,792 feet, viz: 563 feet inside of the tunnel, and 1,229 feet outside. The level of the water inside is upwards of 9 feet below the summit, and the fall outside 29¼ feet, so that the head is a fraction over 20 feet.

Iron faucet pipes of 3 inches interior diameter were adopted. It was feared that larger ones would carry along too much air; and that the syphon would have to be fed too often at the summit, an apprehension which the results observed seem to justify.

A common faucet cock is placed at each end, to close the syphon when it becomes necessary to fill it again with water; and at the

summit a large air vessel is provided to collect the air disengaged from the water, with a suitable opening at top, to let the air out and replace it with water; this opening being closed by a cap tightly screwed down. At the bottom of the air vessel, there is besides a large cock, which is closed while the syphon is being fed through the top opening, so as not to interrupt the running of the syphon during the operation.

The annexed diagram represents the air vessel *a*; *b* is the cap; *c* the cut-off cock; *e* the main pipe or syphon; *d* is a glass tube for observing the level of the water. This, however, being often broken was dispensed with at last; the level of the water being easily ascertained by knocking against the air-vessel.



Things being now disposed as described, it might be supposed that the discharge would have gone on uninterruptedly, requiring only a careful attention to replenish occasionally with water the air vessel; but such was not the case; at first the joints had been made tight by packing with oakum and then thickly pitched over. The syphon was filled with water through the air-vessel, which being then closed and the ends open, the water began to flow; but this did not continue for more than five or ten minutes, when the air vessel was found empty of water, and had to be replenished at these short intervals; moreover, notwithstanding this tedious repetition of feeding the syphon, it would ultimately run dry in about two hours.

This was a truly discouraging circumstance; we ascribed it to the fact that, there being upwards of 200 joints, air was introduced in small bubbles through the oakum packing by the external pressure at every joint, and that it accumulated rapidly all along, especially in the longer arm of the syphon which soon became too light. Accordingly, we decided not to abandon the enterprise, but to caulk the joints with lead in the usual way, which was not done before for motives of economy, and because, it being only a temporary fixture, it would have been more easily taken apart.

This operation was not yet entirely successful, though the caulking was made so hard that many of the bells broke in packing, without making the joints perfectly impermeable. Then a cement was made of equal parts of white lead and red lead mixed to the consistency of soft putty, with equal quantities of Japan varnish and boiled linseed oil. This cement, carefully coated over the joints, made them at last perfectly tight. The syphon thus improved runs

now regularly. Still the air vessel must be replenished with water every two hours, which is done by a pipe leading from a spring, and, moreover, every six hours the ends must be closed, and the whole syphon filled in anew with water; otherwise it would run dry.* It is probable that, owing to its being so long, and consequently so level, bubbles of air travel along very slowly and increase in size gradually; possibly some air may find its way under external pressure through the iron itself.

A curious circumstance took place in the beginning: The tunnel having progressed much beyond the well of the syphon, and the water considerably increased, a horse-power with chain pumps was constructed at the farther end to pump up the water into troughs, by which it is led to the syphon well. Here, the syphon being insufficient for this accession of water, another horse-power was introduced to pump up water out of the same well. As soon, however, as the chain pumps began to revolve in the well, the syphon suddenly stopped and we were obliged to dig a separate well for it; since which time both have worked well.

The syphon, by actual measurement, when just replenished, discharges 43½ gallons per minute, whereas all known formulæ give between 54 and 60 gallons, and furthermore in Weale's *Engineers' and Contractors' Companion* occurs this conflicting remark taken from R. A. Peacocke's work:

"By Dr. Young's formula (considered by him the best)—

A	5-inch	pipe	would	be	used where a	3½ would suffice.
	7	"	"	"	"	5 "
	10	"	"	"	"	7 "
	14	"	"	"	"	10 "

and then he goes on to show the useless expenditure resulting from pipes too large being used in obedience to these formulæ. But here in this extraordinarily long syphon, his opinion is not sustained, and we find, on the contrary, the discharge is less than the formulæ give; and that neither they nor Mr. Peacocke's rules are applicable to this case.

The syphon I have described is, I believe, the longest ever attempted to be used, and on this account the results and anomalies it presents are somewhat interesting. It certainly has rendered considerable service in the Blue Ridge Tunnel; with no other current expense than the employment of a man to attend to the air vessel.

* Would not this be remedied by making the air vessel *self-acting* like the air valves sometimes used on water mains?—J. C. T.

Mechanics, Physics, and Chemistry.

ON THE BLUE COLOR OF THE SKY, THE POLARIZATION OF SKY-LIGHT, AND POLARIZATION OF LIGHT BY CLOUDY MATTER GENERALLY.

By John Tyndall, L.L.D., F.R.S.

(Concluded from page 40.)

But, as regards the polarization of the sky, we know that not only is the direction of maximum polarization at right angles to the track of the solar beams, but that at certain angular distances, probably variable ones, from the sun, "neutral points," or points, of no polarization exist, on both sides of which the planes of atmospheric polarization are at right angles to each other.

I have made various observations upon this subject which I reserve for the present; but pending the more complete examination of the question the following facts and observations bearing upon it are submitted to the Royal Society.

The parallel beam employed in these experiments tracked its way through the laboratory air exactly as sun-beams are seen to do in the dusty air of London. I have reason to believe that a great portion of the matter thus floating in the laboratory air consists of organic germs, which are capable of imparting a perceptibly bluish tint to the air. This air showed, though far less vividly, all the effects of polarization obtained with the incipient clouds. The light discharged laterally from the track of the illuminating beam was polarized, though not perfectly, the direction of maximum polarization being at right angles to the beam.

The horizontal column of air thus illuminated was 18 feet long, and could therefore be looked at very obliquely without any disturbance from a solid envelope. At all points of the beam throughout its entire length the light emitted normally was in the same state of polarization. Keeping the positions of the Nicol and the selenite constant, the same colors were observed throughout the entire beam when the line of vision was perpendicular to its length.

I then placed myself near the end of the beam as it issued from the electric lamp, and looking through the Nicol and selenite more and more obliquely at the beam, observed the colors fading until

they disappeared. Augmenting the obliquity, the colors appeared once more, *but they were now complementary to the former ones.*

Hence this beam, like the sky, exhibited its neutral point, at opposite sides of which the light was polarized in planes at right angles to each other.

Thinking that the action observed in the laboratory might be caused in some way by the vaporous fumes diffused in its air, I had a battery and an electric lamp carried to a room at the top of the Royal Institution. The track of the beam was seen very finely in the air of this room, a length of 14 or 15 feet being attainable. This beam exhibited all the effects observed with the beam in the laboratory. Even the uncondensed electric light falling on the floating matter showed, though faintly, the effects of polarization.*

When the air was so sifted as to entirely remove the visible floating matter, it no longer exerted any sensible action upon the light, but behaved like a vacuum.

I had varied and confirmed in many ways those experiments on neutral points, operating upon the fumes of chloride of ammonium, the smoke of brown paper, and tobacco smoke, when my attention was drawn by Sir Charles Wheatstone to an important observation communicated to the Paris Academy, in 1860, by Professor Govi, of Turin.† His observations on the light of comets had led M. Govi to examine a beam of light sent through a room in which was diffused the smoke of incense. He also operated on tobacco smoke. His first brief communication stated the fact of polarization by such smoke, but in his second communication he announced the discovery of a neutral point in the beam, at the opposite sides of which the light was polarized in planes at right angles to each other.

But unlike my obsevations on the laboratory air, and unlike the action of the sky, the direction of maximum polarization in M. Govi's experiment enclosed a very small angle with the axis of the illuminating beam. The question was left in this condition, and I am not aware that M. Govi or any other investigator has pursued it further.

I had noticed, as before stated, that as the clouds formed in the experimental tube became denser, the polarization of the light discharged at right angles to the beam became weaker, the direction

* I hope to try Alpine air next summer.

† *Comptes Rendus*, tome li. pp. 360 and 369.

of maximum polarization becoming oblique to the beam. Experiments on the fumes of chloride of ammonium gave me also reason to suspect that the position of the neutral point *was not constant*, but that it varied with the density of the illuminated fumes.

The examination of these questions led to the following new and remarkable results:—The laboratory being well filled with the fumes of incense, and sufficient time being allowed for their uniform diffusion, the electric beam was sent through the smoke. From the track of the beam polarized light was discharged, but the direction of maximum polarization, instead of being alone the normal, now enclosed an angle of 12° or 13° with the axis of the beam.

A neutral point, with complementary effects at opposite sides of it, was also exhibited by the beam. The angle enclosed by the axis of the beam, and a line drawn from the neutral point to the observer's eye, measured in the first instance 66°.

The windows of the laboratory were now opened for some minutes, a portion of the incense smoke being permitted to escape. On again darkening the room and turning on the beam, the line of vision to the neutral point was found to enclose with the axis of the beam an angle of 63°.

The windows were again opened for a few minutes, more of the smoke being permitted to escape. Measured as before the angle referred to was found to be 54°.

This process was repeated three additional times; the neutral point was found to recede lower and lower down the beam, the angle between a line drawn from the eye to the neutral point and the axis of the beam falling successively from 54° to 49°, 43° and 33°.

The distances, roughly measured, of the neutral point from the lamp, corresponding to the foregoing series of observations, were these:

1st	observation	2	feet,	2	inches.
2d	"	2	"	6	"
3d	"	2	"	10	"
4th	"	3	"	2	"
5th	"	3	"	7	"
6th	"	4	"	6	"

At the end of this series of experiments the direction of maximum polarization had again become normal to the beam.

The laboratory was next filled with the fumes of gunpowder. In

five successive experiments, corresponding to five different densities of the gunpowder smoke, the angles enclosed between the line of vision to the neutral point and the axis of the beam were 63°, 50°, 47°, 42° and 38°, respectively.

After the clouds of gunpowder had cleared away the laboratory was filled with the fumes of common resin, rendered so dense as to be very irritating to my lungs. The direction of maximum polarization enclosed in this case an angle of 12°, or thereabouts, with the axis of the beam. Looked at, as in the former instances, from a position near the electric lamp *no neutral point* was observed throughout the entire extent of the beam.

When this beam was looked at normally through the selenite and Nicol, the ring system, though not brilliant, was distinct. Keeping the eye upon the plate of selenite and the line of vision normal, the windows were opened, the blinds remaining undrawn. The resinous fumes slowly diminished, and as they did so the ring system became paler. It finally disappeared. Continuing to look along the perpendicular, the rings revived, but now the colors were complementary to the former ones. *The neutral point had passed me in its motion down the beam consequent upon the attenuation of the fumes of resin.*

In the fumes of chloride of ammonium substantially the same results were obtained as those just described. Sufficient, I think, has been here stated to illustrate the variability of the position of the neutral point. The explanation of the results will probably give new work to the undulatory theory.*

Before quitting the question of the reversal of the polarization by cloudy matter, I will make one or two additional observations. Some of the clouds formed in the experiments on the chemical action of light are astonishing as to form. The experimental tube is often divided into segments of dense cloud, separated from each other by nodes of finer matter. Looked at normally, as many as four reversals of the plane of polarization have been found in the tube in passing from node to segment, and from segment to node. With the fumes diffused in the laboratory, on the contrary, there was no change in the polarization along the normal, for here the necessary differences of cloud-texture did not exist.

* Brewster has proved the variability of the position of the neutral point for skylight with the sun's altitude. Is not the proximate cause of this revealed by the foregoing experiments?

Further. By a puff of tobacco smoke or of condensed steam blown into the illuminated beam, the brilliancy of the colors may be greatly augmented. But with different clouds two different effects are produced. For example, let the ring system observed in the common air be brought to its maximum strength, and then let an attenuated cloud of chloride of ammonium be thrown into the beam at the point looked at; the ring system flashes out with augmented brilliancy, and the character of the polarization remains unchanged. This is also the case when phosphorus or sulphur is burned underneath the beam, so as to cause the fine particles of phosphoric acid or of sulphur to rise into the light. With the sulphur fumes the brilliancy of the colors is exceedingly intensified; but in none of these cases is there any change in the character of the polarization.

But when a puff of aqueous cloud, or of the fumes of hydrochloric acid, hydriodic acid or nitric acid is thrown into the beam, there is a complete reversal of the selenite tints. Each of these clouds twists the plane of polarization 90°. On these and kindred points experiments are still in progress.*

The idea that the color of the sky is due to the action of finely divided matter, rendering the atmosphere a turbid medium, through which we look at the darkness of space, dates as far back as Leonardo da Vinci. Newton conceived the color to be due to exceedingly small water particles acting as thin plates. Goethe's experiments, in connection with this subject, are well known and exceedingly instructive. One very striking observation of Goethe's referred to what is technically called "chill" by painters, which is due no doubt to extremely fine varnish particles interposed between the eye and a dark background. Clausius, in two very able memoirs, endeavored to connect the colors of the sky with suspended water-vesicles, and to show that the important observations of Forbes on condensing steam could also be thus accounted for. Brücke's experiments on precipitated mastic were referred to in my last abstract. Helmholtz has ascribed the blueness of the eyes to the action of suspended particles. In an article written nearly nine years ago by myself,

* Sir John Herschel has suggested to me that this change of the polarization from positive to negative may indicate a change from polarization by reflection to polarization by refraction. This thought repeatedly occurred to me while looking at the effects; but it will require much following up before it emerges into clearness.

the colors of the peat smoke of the cabins of Killarney* and the colors of the sky were referred to one and the same cause, while a chapter of the "Glaciers of the Alps," published in 1860, is also devoted to this question. Roscoe, in connection with his truly beautiful experiments on the photographic power of sky-light, has also given various instances of the production of color by suspended particles. In the foregoing experiments the azure was produced in *air*, and exhibited a depth and purity far surpassing anything that I have ever seen in mote-filled liquids. Its polarization, moreover, was *perfect*.

In his experiments on fluorescence Professor Stokes had continually to separate the light reflected from the motes suspended in his liquids, the action of which he named "false dispersion," from the fluorescent light of the same liquids, which he ascribed to "true dispersion." In fact it is hardly possible to obtain a liquid without motes, which polarize by reflection the light falling upon them, truly dispersed light being unpolarized. At p. 530 of his celebrated memoir "On the Change of the Refrangibility of Light," Prof. Stokes adduces some significant facts, and makes some noteworthy remarks, which bear upon our present subject. He notices more particularly a specimen of plate glass which, seen by reflected light, exhibited a blue which was exceedingly like an effect of fluorescence, but which, when properly examined, was found to be an instance of false dispersion "It often struck me," he writes, "while engaged in these observations, that when the beam had a continuous appearance, the polarization was more nearly perfect than when it was sparkling, so as to force on the mind the conviction that it arose merely from motes.† Indeed, in the former case the polarization has often appeared perfect, or all but perfect. It is possible that this may in some measure have been due to the circumstance, that when a given quantity of light is diminished in a given ratio, the illumination is perceived with more difficulty when the light is

* I have sometimes quenched almost completely, by a Nicol, the light discharged normally from burning leaves in Hyde Park. The blue smoke from the *ignited end* of a cigar polarizes also, but not perfectly.

† The azure may be produced in the midst of a field of motes. By turning the Nicol, the interstitial blue may be completely quenched, the shining, and apparently unaffected motes, remaining masters of the field. A blue cloud, moreover, may be precipitated in the midst of the azure. An aqueous cloud thus precipitated reverses the polarization; but on the melting away of the cloud the azure and its polarization remain behind.

diffused uniformly, than when it is spread over the same space, but collected into specks. Be this as it may, there was at least no tendency observed towards polarization in a plane perpendicular to the plane of reflection, when the suspended particles became finer, and therefore the beam more nearly continuous."

Through the courtesy of its owner, I have been permitted to see and to experiment with the piece of plate glass above referred to. Placed in front of the electric lamp, whether edgeways or transversely, it discharges bluish polarized light laterally, the color being by no means a bad imitation of the blue of the sky.

Prof. Stokes considers that this deportment may be invoked to decide the question of the direction of the vibrations of polarized light. On this point I would say, if it can be demonstrated that when the particles are small in comparison to the length of a wave of light, the vibrations of a ray reflected by such particles cannot be perpendicular to the vibrations of the incident light; then assuredly the experiments recorded in the foregoing communication decide the question in favor of Fresnel's assumption.

As stated above, almost all liquids have motes in them sufficiently numerous to polarize sensibly the light, and very beautiful effects may be obtained by simple artificial devices. When, for example, a cell of distilled water is placed in front of the electric lamp, and a slice of the beam is permitted to pass through it, scarcely any polarized light is discharged, and scarcely any color produced with a plate of selenite. But while the beam is passing through it, if a bit of soap be agitated in the water above the beam, the moment the infinitesimal particles reach the beam the liquid sends forth laterally almost perfectly polarized light; and if the selenite be employed, vivid colors flash into existence. A still more brilliant result is obtained with mastic dissolved in a great excess of alcohol.

The selenite rings constitute an extremely delicate test as to the quantity of motes in a liquid. Commencing with distilled water, for example, a thickish beam of light is necessary to make the polarization of its motes sensible. A much thinner beam suffices for common water; while with Brücke's precipitated mastic, a beam too thin to produce any sensible effect with most other liquids, suffices to bring out vividly the selenite colors.

CONTROLLING THE ARMATURES OF ELECTRO-MAGNETIC INDUCTION MACHINES.

By Mr. Henry Wilde.

This was a paper on a Property of the Electric Current to Control and Render Synchronous the Rotations of the Armatures of a Number of Electro-magnetic Induction Machines, read before the Manchester Literary and Philosophical Society.

The discovery of the property which the author describes arose out of the efforts which have been made, during the last two years, to reduce the internal heat generated in large electro-magnetic machines by the rapid magnetization and demagnetization of the armatures. By constructing the machines of smaller dimensions, this heating was considerably diminished; but an inconvenient residuum of heat still remained when the machines were worked continuously for a long time, such as to render it desirable to adopt some means for abstracting the heat more rapidly.

By means of a current of water, circulating in the hollow brass segments which form part of the magnet-cylinder, Mr. Charles E. Ryder, the skillful manager at the works of Messrs. Elkington & Co., has happily succeeded in so far reducing this heating as to permit of the machines being worked, for days and nights together, without intermission, and without any sensible diminution of the power of the current.

The author has already shown, elsewhere, that the current from a small magneto-electric or electro-magnetic machine is sufficient to excite the electro-magnet of a very large machine: and it has been further found, by Mr. G. C. Lowe, that the current from one small machine is sufficient to excite, simultaneously, the electro-magnets of several small machines. In a number of 3½-inch machines which have been constructed, under the author's direction, for Messrs. Elkington & Co., for the electro-deposition of copper on a large scale, the current from two 3½-electro-magnetic machines are made to excite the electro-magnets of twenty similar sized machines to a degree sufficient to bring out the maximum dynamic effect of each machine.

The electro-magnets of two 3½-inch exciting machines are charged by the current from a small magneto-electric machine; but the author has found that nearly as good a result may be obtained from

the twenty machines, by dispensing with the small magneto-electric machine, and employing the residual magnetism of the two 3½-inch exciting machines, in a manner similar to that described almost simultaneously by Mr. Farmer, Messrs. Varley, Mr. Siemens and Sir Charles Wheatstone.

While the subdivisions of the materials of one large machine into a number of small ones was attended by several important advantages, yet it was found necessary to adopt some means to secure the synchronous relation of the armatures, when the combined direct current from several machines was required.

As the high speed at which the armatures were driven precluded the employment of toothed gearing, the only method which seemed at all feasible for producing the requisite synchronism was to place several machines in a straight line, and connect them together by means of a clutch fixed on the end of each armature spindle. It was while experimenting with a pair of machines so geared together that the author first observed the phenomenon which forms the subject of his communication.

The armatures of these machines were 4 inches in diameter, and each of them was coiled with a copper wire conductor, 280 feet long and ⅛ inch in diameter. The currents were taken from the armatures by means of copper brushes rubbing against metal rings connected respectively with the ends of the armature coils, and were therefore in alternate directions for producing the electric light.

The clutch by which the armatures were connected consisted of two iron disks, about 4 inches in diameter, having in the face of one, two iron pins which could be guided into two corresponding holes in the face of the other. These disks could be engaged, or disengaged, either when the machines were at rest or in motion. The relative positions of the pins and holes in the disks were such that the armatures might be engaged in reversed positions of half a revolution, when required.

Each of the machines, when making about 2,000 revolutions per minute, was, of itself, capable of producing a very efficient electric light; and when the two armatures were clutched together in such a position that the united positive currents from both machines should proceed from one polar terminal, simultaneously with the united negative currents from the other polar terminal, the sum of the currents from the two machines was obtained. On the other hand, when the armatures were clutched together in the reversed

position, without any change being made in the armature connections, no current was produced outside the two machines.

These experiments, besides exhibiting the necessity of synchronous rotation, further showed that the armatures must also occupy the same relative position in the magnet cylinders, in order that the combined currents from the two machines might be obtained. It now occurred to the author to see to what extent the want of synchronism in the armatures would affect the magnitude of the current.

The armatures were therefore unclutched, and allowed to revolve independently of each other, in the same manner as when the attempt was made to take the combined direct current from the commutators. After the alternating current had been transmitted through the electric lamp for some time, it was found that there was no perceptible diminution in the amount of light produced from the carbon points, and that the current would melt, very nearly, the same quantity of iron wire as when the armatures were clutched together. On examining into the circumstances attending this unexpected phenomenon, it was first observed that whenever the machines were stopped, the pins and holes in the respective disks were exactly opposite each other; and that, while the armature were revolving, the two disks could at all times be engaged and disengaged with the greatest facility. Moreover, even when the disks were set (before starting the machine) a quarter, or half a revolution, out of the position in which the maximum amount of current was obtained, it was found that after the armatures had been revolving for a few moments, the disks resumed their normal positions with respect to each other (as indicated by the action of the clutch); thereby exhibiting, not only the synchronous rotation of the armatures, but also, that the machines contained a principle of self-adjustment to the position in which the maximum effect of the combined current was obtained. It was therefore evident that this property of the current, to maintain the synchronism of the armatures, rendered it unnecessary to employ mechanical gearing of any kind for that purpose.

The author then proceeds to enter into a detailed explanation of the causes which produce the synchronism of the armatures, a summary of which is as follows:—When the armatures happen to be in that position during their revolution in which they are producing the maximum and minimum amount of current respectively (as

must often be the case when there is no synchronism), that current which is at the maximum rushes through the coil which is producing the minimum amount of current,—the effect of this passage of the current from one coil to the other being to accelerate or retard the rotation of the armature (according to the direction of the current) until synchronism is established. On the other hand, the absence of synchronism observed when the direct current was taken from the machines, by means of commutators, is caused by the direction of the currents being coincident with that which they would receive by induction from the electro-magnets, and, consequently, opposite to that which tends to impart an accelerating or retarding impulse to the armatures.

The synchronous rotations of the armatures having been secured in the case of the combined alternating currents, it yet remained to obtain the combined direct currents from the two machines. A pair of rings and a commutator were therefore fitted upon one of the armature spindles, which was made sufficiently long for the purpose; and metallic connection was established between the rings of each machine and the commutator on the prolongation of the armature axis. As the commutator necessarily revolved synchronously with the two armatures, it was found that the combined alternating currents were rectified, just as if they had proceeded from only one machine; and were, consequently, available for electro-deposition, or for any other purpose for which a direct current might be required.

Although this property of synchronous rotation has, as yet, been observed only in the case of several pairs and a triple combination of machines, yet the author sees no reason for supposing that it may not be extended to any number of machines that may be conveniently worked together from the same prime mover. It is necessary, however, to observe that, as the controlling power of the current is only calculated to correct such minute deviations from synchronism as it is beyond the power of mechanical skill to prevent, the driving and driven pulleys should be, respectively, as nearly as possible of the same diameters, as the correction of any considerable difference in the number of the revolutions of the armatures, caused by differences in the diameters of the pulleys, must necessarily be attended by a corresponding diminution of the useful effect of the current outside the machines.

The author concludes his communication by directing attention

to an important property of the magneto-electric circuit, which renders the commonly accepted theory by which the generation and propagation of the electric influence in voltaic circuits is explained, inapplicable to those circuits which are entirely metallic. Reference to this property is all the more called for at the present time, as the author finds that a want of acquaintance with it has given rise to no small amount of misconception on the part of several eminent mathematicians and electricians, who have examined his experiments on the electric condition of the earth, and the method by which he has thought proper to estimate the magnitude of powerful induction currents.*

The intensity of a voltaic current, as represented by the mathematical theory of Ohm, is equal to the electro-motive force divided by the internal resistance of the battery; and from this theory it is inferred than an electro-motor, in order to overcome a great external resistance, must itself possess a correspondingly great internal resistance. A further consequence deduced from this theory is, that the maximum useful effect of a given electro-motor is obtained when the external and internal resistances are equal.

Now, this mode of estimating the magnitude of an electric current does not apply to the circuits on the armatures of the machines invented by the author. Take, for example, the results obtained from the quantity armature of a 10-inch machine. The dimensions of the coil of this armature may be represented by a bar of pure copper 67 feet long, and having a sectional area of 1·6 square inches, so that the resistance which this circuit presents to the passage of a current, when compared with that of the liquids in a voltaic battery, is practically null. When the coil is in full action it will melt 15 inches of thin iron wire ·035 inch in diameter, or the same length of ¼ inch iron rod with equal certainty; and will electrolize acidulated water in at least 16 voltameters in series: so that the resistance outside the circuit, whether estimated by the 15 inches of thin wire melted, or by the number of electrolizing cells in series, is more than one hundred times greater than that of the coil in which the current is generated.

Moreover, the author has found that whenever a voltaic battery and a magneto-electric machine will melt an equal length of wire, the power which these electro-motors have to overcome external

* *Philosophical Magazine*, August, 1868.

resistance, as measured by the number of voltameters in series, is also equal. And generally the power of an electro-motor (whether voltaic or magneto-electric) to overcome external resistance, is directly proportionate to the length of wire which it will melt.

From a consideration of these results it will be seen that one of the fundamental elements which enters into the theory of Ohm is found wanting when that theory is applied to the estimation of the magnitude of currents generated in circuits entirely magnetic. M.M. Jamin and Roger, in a recent number of the *Comptes Rendus*, of the Academy of Sciences, have also pointed out the discrepancy here referred to in the application of Ohm's theory to magneto-electric circuits. The author is, however, by no means prepared to admit the correctness of the views advanced by these physicists in their endeavors to reconcile the facts observed, with established theory, besides which other anomalies present themselves when the customary formulæ are applied to magneto-electric circuits, a consideration of which must, as the author affirms, lead ultimately to the enunciation of laws much more general in their application than those with which we are at present familiar.

THE CAPTIVE BALLOON.

Six months since we penned some remarks upon the interesting features which presented themselves to the scientific mind when up in a balloon. We then observed that in a very short space of time any one who had not been up in a balloon would be regarded as one behind his time, and would be placed in the same category as those who had never ridden in a Hansom cab, nor traveled on a railway. The time to which we then looked forward has arrived, and it is now open to any one who likes to take boat, 'bus, or rail to Chelsea, to make an ascent in one of the finest and best appointed balloons that ever floated in the air. This splendid aerostat is the property of M. Giffard, the inventor of the well known injector, and by whom it was constructed. It is now on view in the Ashburnham Park, Chelsea, where it is daily making captive ascents—weather permitting. In one of these ascents we had the pleasure of joining yesterday week, on the invitation of the proprietor, and which ascent we briefly recorded in our last number. On that occasion, Mr. Glaisher made the ascent with the view of taking

some meteorological observations near the earth, which the gradual ascent of a captive balloon would permit of, and which he had not been able to take in a free balloon, owing to the rapidity with which it always left the earth. On that occasion, too, there were present Lord Richard Grosvenor and Lord Dufferin, members of the council of the Aeronautical Society of Great Britain, Mr. Brearey (the secretary), Mr. T. Cargill, C. E., and several other scientific gentlemen. But the elements were unpropitious; a stiff breeze suddenly sprang up, which obliged the party to return to earth after an altitude of about 2,000 feet had been reached. The circumstance, however, served to show how perfect all the arrangements were, and how thoroughly under control the immense machine was. As we made the ascent shortly before going to press, we had not time to place the details of the apparatus before our readers; we, however, propose to do so now.

Those who visited Paris during the last Great Exhibition will, doubtless, remember M. Giffard's captive balloon, and the machinery by which the ascents and descents were regulated. This machinery has now been brought to London, together with a balloon 23 feet larger in diameter than the Paris balloon, and a rope of much greater length. On entering the Ashburnham Park, the visitor finds himself in a circus 246 feet in diameter, encircled by a screen of timber framing 80 feet in height, and covered with canvas. In the centre of this arena is a well about 15 feet deep, over which the balloon, when not on a journey, is held in place by numerous guy ropes. This balloon is 93 feet in diameter, and when inflated contains 421,161 cubic feet of gas, pure hydrogen being the gas used. The material of which the balloon is constructed is composed of one layer of linen interior, united to another layer of the same material, by means of a solution of india-rubber. Outside this is a layer of Cretonne linen, the attachment being formed by a vulcanized india-rubber composition. The exterior is finished with two coats of gum shellac varnish, over which again are laid fine coats of boiled linseed oil. From the balloon is suspended a circular car, having the centre open for the passage of the rope, which is attached directly to the body of the balloon. The car will accommodate about twenty-five persons; this was, in fact, the number that made the ascent to which we have referred. The rope is made fast to a pressure gauge, having a horizontal dial, upon which a pointer indicates the strain put upon the rope at any

moment. The balloon weighs 6,000 pounds; the core netting, with which it is covered, and the necessary guy ropes, &c., which are very numerous, are stated to weigh 4,000 pounds.

The main rope by which the balloon is held captive, weighs 4,350 pounds, is 2,150 feet in length, and is 2¾ inches in diameter at the end next the balloon, gradually tapering to 2 inches diameter at the end next the winding drum. The object of thus tapering the rope, is that its weakest part may be nearest the ground, at which point it would first give way, if it broke at all—which is hardly probable. By this means, if such an event did take place, there would be no danger to those below, from a heavy mass of rope falling upon them. It would also act somewhat as a brake upon the balloon, which would otherwise shoot upwards at a terrific rate, when suddenly relieved of its load. The rope passes from the balloon over a pulley wheel 5 feet 6 inches in diameter, which is so arranged that it allows the rope to pass freely over it, no matter what angle it may take. It is, in fact, swivelled horizontally and vertically, and has a heavy counterbalance weight attached to it. This pulley wheel is held down by a strong frame work, which is built into the earth, and is weighted with 50 tons of brick, iron and timber work. The rope passes horizontally from the pulley along a gradually widening tunnel to the winding drum which is placed at the far side of the circus. This drum is 23 feet in length, and 7 feet in diameter. It is cast in lengths, and is grooved to receive the rope. The drum is surrounded by a platform, at each end of which is a double cylinder steam engine of horizontal construction. These engines drive the drum by means of toothed gearing; they receive steam from two vertical boilers placed in the rear of the circus. The boilers are of French construction, by M. Duresnes, as are also the engines, which are by M. H. Flaud The winding drum was made in London by M. Babeaud, the engineer in charge of the balloon machinery.

On a piece of spare ground in the rear of the circus is the apparatus for producing the gas. This consists of a series of wooden vats in which scrap iron is placed in a solution of sulphuric acid. The gas is drawn off to a receiver, and is made to pass through a washer and a purifier, after which it is stored in a gas holder ready for use. The balloon is always kept inflated, but there is always a loss going on from condensation, the deficiency being made good every evening. The cost of the balloon and apparatus has been

something considerable, as will be seen from the following items: Cost of balloon £2,000; netting, guy, and other necessary ropes, £2,000; main holding-rope, £220; engines, boilers, and machinery to work the balloon, £4,000; gas works, £1,200. These items —which are not all that could be enumerated—represent the respectable sum of £9,420, and when we add that the gas for one inflation costs £600, it will be seen that M. Giffard has made an investment of no light nature, but which we trust will prove as satisfactory to himself as his balloon will prove attractive to the public. A careful examination of the whole apparatus has satisfied us that everything is as safe as human ingenuity and foresight can make it. Two experienced aeronauts, MM. Godard and Aymo, accompany each ascent, whilst the manager is M. Yon, who manufactured the whole of the ropes and netting, and also constructed the balloon for M. Giffard. We can but wish success to this novel enterprise, which we are sure will be well patronized by the public, whenever the weather will permit of ascents being made. There is now no excuse for the public not enjoying the privilege of a balloon ascent, which luxury has hitherto only been allowed to a select few.

ON THE NEW CHEMICAL NOMENCLATURE.

By Dr. Adolph Ott.

"We must acknowledge that the present system of nomenclature must be abandoned, in order to give the true science of chemistry a rapid and onward impulse." —*James C. Booth*, 1862.

The deficiency of the present system of chemical nomenclature, though immensely felt for many years, has chiefly been brought to light by the late astonishing strides of organic chemistry, or the chemistry of "carbon compounds," as termed by Kolbe. Here, the application of the principles predominating in mineral chemistry, resulted in the formation of names of such considerable length, that though indicating the composition of the respective bodies, they can scarcely be retained in the memory, are apt to mislead the novice in a thousand ways, and seriously to prejudice him at first against one of the most useful and interesting sciences. What shall we say of names with seventeen or more syllables, such as every text-book on organic chemistry now abounds with? And when it is known, as a distinguished writer asserts, that "the cata-

logue of the infinite number of substances which organic chemistry embraces, will shortly exceed that elaborated by astronomers for the stars themselves," it will be the better understood how great a drawback the retaining of the present scheme of nomenclature must be for the science referred to. Though in a less distinct manner, this deficiency has also been long felt in the domain of inorganic chemistry. We also meet here with scarcely pronounceable denominations, as "hypersulphomolybdate of potassa," "sesquibasico ammoniao-sulpharseniate of soda," "triphosphofluor-calcium," and many others; still their number is less, and they are therefore less conspicuous. We might for this reason also substitute empiric names for them. This system, however, evidently could not be well carried out in the domain of organic chemistry. The present scheme of chemical nomenclature is, moreover, not equal to the high demands of science, for reasons which shall be stated hereafter. Indeed, it cannot be considered as the expression of a system, since it must be learned as a language, which, in many cases is even so imperfect, that formulæ alone can give us a correct idea of the composition of bodies. Such is the present condition of chemical nomenclature.

Laurent in his "Chemical Methods," admits that "the problem of chemical nomenclature is so beset with difficulties, that from a thorough examination of them, we should be inclined to renounce the task of solution." Fortunately for the progress of science, these difficulties have been surmounted by an American savant, who in view of the words of *Regnault* that "chemical nomenclature can no longer be altered materially without great inconvenience," has invented an entirely new scheme, which in spite of its originality (and this is its great merit), is nevertheless built up in a true conservative spirit, and upon the foundation laid by the great men, who devoted their lives to the advancement of chemistry. It is self evident that a system like this must at once command our highest interest and participation.

It was first proposed at the meeting of the American Association for the Advancement of Science, held in the City of Buffalo, August, 1866, by the worthy Professor of Technology in the American Institute of the City of New York, *S. D. Tillman, L.L.D.*, and is found published in extenso in the proceedings of the above mentioned association, issued by Joseph Lovering, in Cambridge, in 1868.

In order to be able more fully to appreciate its high claims, we propose to devote some space to the rise and progress of chemical nomenclature.

The history of the spoken language of chemistry shows more clearly than that of any other science its various conditions in the succeeding stages of progress. The early cultivators of science hid their doctrines under the veil of an obscure, figurative, and enigmatic language, adopting at the same time, particular characters for signifying the various bodies known to them. In the belief that the celestial bodies exercised a direct influence on terrestrial products, they consecrated the metallic and other substances to the seven so-called planets. To Saturn were consecrated the lead, the litharge and agate; to Jupiter, the tin, corals, all white stones, the sandarac and the sulphur; to Mars, the iron, the loadstone, and the pyrites; to the Sun, the gold, the carbon, the diamond, the sapphire and hyacinth; to Mercurius, the quicksilver, etc.; to the Moon, the silver, etc., etc. Traces of this nomenclature yet remain in terms. as *Arbor Dianæ*, *tincture of Mars*, *Martial pyrites*, *Lunar caustic*, mercury, (which latter term has become universally employed) and others. The term *sal* is used since the oldest times, for everything tasting like salt, or even for substances, as the carbonate of potassa, which share only some properties with the same, viz., solubility in water, deliquescence and color. At a latter period, words referring to the origin of the respective substance are added thereto. Thus we have the expressions, *sal marinum*, *sal ammoniacum*, *sal petræ*, *or nitri*; *sal vegetabile* for potash, is also used at quite an early date. We find figurative expressions also quite frequently introduced into nomenclature. Alcohol* was called *aqua ardens*, *sal ammoniæ*, *amina sensibilis*, *cancer*, *lapis aquilinis*, *aqua duorum*, *fratrium*, *ex sorrore*, etc.

Yeber or *Geber* (ninth century), who first made us acquainted with the preparation of nitric acid and aqua regia, calls the former *aqua dissolutiva*, and so he designates the liquid obtained in subjecting alum to heat in a retort and collecting the rising vapors.

From the thirteenth to the eighteenth century, the various compounds are briefly denominated according to physical properties, or slight resemblances in some external characters to domestic articles.

* This word is derived from a Chaldaic verb, which signifies *to burn*, or *to terrify*.

We refer to names like *oleum vitrioli*, *rheum tartari*, *oleum martis*,* names which to some extent justify Dumas' in saying: "*Les chimistes semblaient avoir emprunté le langage des cuisinieres.*"

Spiritus fumans, *flores zinci*, *flores sulphuris*, are other names, expressing various significations. The term *salt* obtained still a wider signification than it possessed in ancient times. *Palissy*, the cotemporary of *Agricola* and *Paracelsus*, and himself the representant of a speedily growing science, in his treatise on "*Des sels divers*," embraces under the term *salt*, saltpetre, vitriols, alum, borax, sugar, sublimat, cream of tartar, and sal ammoniæ. Metallic bodies of an orange color were called *crocus*; *æthiops* if of a black one.

With the discovery of a greater number of compounds, especially of salts, which were lacking remarkable properties, recourse was had to the names of the discoverers. Thus the names *sal mirabile glauberi*, *sal polychrestum glaseri* took their origin. During the period of alchemistry, nearly every chemist created his own nomenclature, only for the common substances, the expressions coincide greatly with each other. Towards the close of the seventeenth century, chemists agreed finally to establish similar names on the similarity of properties. The sulphates were distinguished as *vitriols*, the nitrates as *nitres*. The condition of chemical nomenclature as late as in the commencement of the eighteenth century may, however, be inferred from the fact that the black oxide of manganese was called *magnesia nigra*, in opposition to the *magnesia alba*, because it was supposed that these bodies were greatly similar to each other.

(To be continued.)

ON AN EASY METHOD OF MEASURING APPROXIMATELY THE INTENSITY OF TOTAL DAYLIGHT.

By Roger J. Wright, Esq.

An easy method by which the amount of light may be at any time measured and registered, appears to be still wanting. I would suggest the following plan, by which I believe the desired object may may be attained.

We have a rod of solid metal, terminated by a heavy base, which keeps the rod in a perpendicular position, also a hollow tube, blackened inside, of such a diameter as exactly to fit and slide over the

* The Persian alchemist, *Rhasès* (860–940), according to *Hœfer* (vide his "Histoire de la chimie," I. 323), makes first mention of an *oil* obtained by submitting the atramentris (sulphate of iron) to distillation. Hœfer is even of the belief that this oil, our oil of vitriol, was known before Rhasès, in an epoch when the distillation was one of the principal manipulations of the chemist, as it is also to-day.

rod. The upper extremity of the rod is painted of a snowy white, with a jet black spot in the centre. On the rod is marked the scale, beginning with zero at the base. The tube is pushed over the rod till the lower extremity coincides with the zero line.

The method of using this instrument is as follows:—Draw the tube gently up the rod, at the same time looking steadily at the black spot before mentioned. It will be found, as the tube ascends, that the black spot will gradually disappear, and ultimately vanish in the gloom; it will also be found that on *different* days, and *different hours* of the *same day*, the *point at which the black spot vanishes* will *vary with the intensity* of the light. This point is read off on the graduated scale, and thus we are enabled to measure the intensity of the light at any required time. In taking an observation, it would be well to state whether that portion of sky round the zenith from which the cone of rays proceeds be clear or cloudy.

It will be seen that the result obtained by this method is not *scientifically* correct, as it will be affected by the eyesight of the person who makes the observation, but only in a slight degree. The method of measuring light, as just described, has been known to me for upwards of three years. The hope that I should some day be enabled to make the instrument *scientifically* correct, has hitherto prevented me from making it public. As I understand that it is highly desirable to have some means of estimating the changes in the light which will occur during the total eclipse of the sun in August next, I no longer feel justified in keeping in the back-ground an instrument which may *possibly* be of some slight assistance.

ON THE MEASUREMENT OF THE LUMINOUS INTENSITY OF LIGHT.

By William Crookes, F.R.S., &c.

The measurement of the luminous intensity of a ray of light is a problem, the solution of which has been repeatedly attempted, but with less satisfactory results than the endeavors to measure the other radiant forces. The problem is susceptible of two divisions, the absolute and the relative measurement of light.

A relative photometer is one in which the observer has only to ascertain the relative illuminating powers of two sources of light, one of which is kept as uniform as possible, the other being the light whose intensity is to be determined. It is therefore evident that one great thing to be aimed at is an absolutely uniform source of light. In the ordinary process of photometry the standard used is a candle, defined by Act of Parliament, as a "sperm of six to the pound, burning at the rate of 120 grains per hour." This, how-

ever, is found to be very variable, and many observers have altogether condemned the employment of test-candles as light-measures.

The author has taken some pains to devise a source of light which should be at the same time fairly uniform in its results, would not vary by keeping, and would be capable of accurate imitation at any time and in any part of the world by mere description. The absence of these conditions seems to be one of the greatest objections to the sperm-candle. It would be impossible for an observer on the continent, ten or twenty years hence, from a written description of the sperm-candle now in use, to make a standard which would bring his photometric results into relation with those obtained here. Without presuming to say that he has satisfactorily solved all difficulties, the writer believes that he has advanced some distance in the right direction, and pointed out the road for further improvement.

A glass lamp is taken of two ounces capacity, the aperture in the neck being 0·25 inch in diameter; another aperture at the side allows the liquid fuel to be introduced; this consists of alcohol of sp. gr. 0·805, and pure benzol boiling at 81° C., which are mixed together in the proportion of five volumes of the former and one of the latter. The wick-holder consists of a platinum tube, and the wick is made of fifty-two pieces of platinum wire, each 0·01 inch in diameter. The flame of this lamp forms a perfectly shaped cone, the extremity being sharp, and having no tendency to smoke; without flicker or movements of any kind, it burns when protected from currents of air at a uniform rate of 136 grains per hour.

These is no doubt that this flame is very much more uniform than that of the sperm-candle sold for photometric purposes. Tested against a candle, considerable variations in relative illuminating power have been observed; but on placing two of these lamps in opposition, no such variations have been detected.

The instrument devised for measuring the relative intensities of the standard and other lights is next described; it has this in common with that of Arago described in 1833, as well as with those described in 1853 by Bernard, and in 1854 by Babinet, that the phenomena of polarized light are used for effecting the desired end.* But it is believed that the present arrangement is quite new, and it

* Since writing the above, I have ascertained that M. Jamin had previously devised a photometer in which the principle adopted in the one here described is employed, although it is carried out in a different, and as I believe, a less perfect manner.—W. C., Dec. 16, 1868.

certainly appears to answer the purpose in a way which leaves little to be desired. The instrument cannot be described without the aid of drawings which accompany the original paper, but its mode of action may be understood by the following description.

The standard lamp being placed on one of the supporting pillars which slide along a graduated stem, it is moved along the bar to a convenient distance, depending on the intensity of the light to be measured. The light to be compared is then fixed in a similar way on the other side of the instrument. On looking through the eyepiece two brightly luminous disks will be seen, of different colors. one of the lights must now be slid along the scale until the two disks of light, as seen in the eyepiece, are equal in tint. Equality of illumination is easily obtained; for, as the eye is observing two adjacent disks of light which pass rapidly from *red-green* to *green-red*, through a neutral point of no color, there is no difficulty in hitting this point with great precision. Squaring the distance between the flames and the centre will give inversely their relative intensities.

The delicacy of this instrument is very great. With two lamps, each about 24 inches from the centre, it is easy to distinguish a movement of one of them to the extent of one-tenth of an inch to or fro, and by using the polarimeter an accuracy exceeding this can be attained.

The employment of a photometer of this kind enables us to compare lights of different colors with one another. So long as the observer, by the eyepiece alone, has to compare the relative intensities of two surfaces respectively illuminated by the lights under trial, it is evident that, unless they are of the same tint, it is impossible to obtain that absolute equality of illumination in the instrument which is requisite for a comparison. By the unaided eye one cannot tell which is the brighter half of a paper disk illuminated one side with a reddish, and on the other with a yellowish light; but by using the photometer here described, the problem becomes practicable. When the contrasts of color are very strong (when, for instance, one is a bright green and the other scarlet), there is difficulty in estimating the exact point of neutrality: but this only diminishes the accuracy of the comparison, and does not render it impossible, as it would be according to other systems.

EDUCATIONAL

SPECTRUM ANALYSIS.

By Prof. Henry Morton, Ph. D.

(Continued from page 62.)

The first of the general laws of spectrum analysis, as deduced by its founders, Kirchhoff and Bunsen, was that, while solids and liquids, either in mass or separated in fine particles, when incandescent, emitted light of continuously various rates of motion, (*i. e.* of all the intermediate rates between their extreme ones); incandescent gases, on the contrary, emitted rays of only a limited number of definite rates.

Consequently, when the light from a solid or liquid is decomposed by the action of a prism, as explained in our former paper, it will yield a continuous spectrum, because every shade of color between those constituting the extremes is present, and will, therefore, fill its appropriate intermediate place; but the light from a gas or vapor, on the other hand, will yield an interrupted spectrum, consisting of bright lines with blank or dark spaces between them, because only certain rates of vibrations or colors are present, and the intermediate ones are wanting.

It was, at first, supposed that the number and position of lines in gaseous spectra were unaffected by the temperature of the gas, but were always the same, for the same substance, even when in different combinations with other elements.

Subsequent researches have served to modify these conclusions in certain respects as we shall proceed to show.

Drs. Frankland and Tyndall, in 1861, both about the same time observed by accident that in the electric arc Lithum developed a brilliant blue line in its spectrum which is not found when it is heated in a Bunsen burner, or even in the oxohydrogen flame.—*Phil. Mag.*, 1861, p. 473. Again, in 1865, Prof. Plucker, of Bonn, observed that by variously modifying the intensity of an electric

discharge through Geissler tubes containing rarefied gases and vapors, at least two and sometimes three entirely distinct spectra might be developed from the same element, and that under certain conditions of great intensity, the lines were so expanded as to produce a sensibly continuous spectrum even from a rarefied gas, (see *Phil. Trans.*, 1865, Vol. CLV., p. 20; also this *Journal*, Vol. LVII., p. 271.) Yet again, in 1867, Dr. Frankland, in a lecture on the "Source of Light in Luminous Flames," reprinted in this *Journal*, Vol. LVII, p. 330, showed that vapors and gases under certain conditions might yield continuous spectra.

Lastly, with regard to the effect of composition with other elements we have the researches of M. E. Diacon, published fully, with illustrations, in the *Ann. de Chem. et de Phys.*, Sept., 1865, and in abstract in *Chemical News*, 1865, p. 243.

It was here proved that under such special conditions as, for example, heating a chloride in a flame of hydrogen and chlorine out of contact with air, the spectra of some substances was entirely altered, and that of others much modified, though with some, no change was produced.

All these modifications of the general law imply special and marked conditions, however, which it is impossible not to recognise, and thus we may practically regard the general law that the spectrum lines of each substance are fixed characteristics, and that discontinuous spectra indicate a gaseous state, as generally reliable.

The most remarkable applications of this law which have been made, are to the investigation of the constitution of nebulæ and comets and to the luminous prominences or flames seen around the sun during total eclipses.

With regard to the first, we will here only note that Messrs. Huggins and Miller, by a series of observations, of which a more complete account is given in this *Journal*, Vol. L., p. 284, showed that while some nebula gave a continuous spectrum, and were, therefore, presumably composed of star-clusters, others gave spectra of a few bright lines only, chiefly corresponding with hydrogen and nitrogen gases, and were, therefore, presumably not of stellar, but of truly nebulous composition.

Spectrum B, on Fig. 1, shows the normal nebular spectrum, A, giving the most prominent lines of nitrogen, oxygen, magnesium and (Na) sodium.

By this means a new light was thrown upon the nature and condition of these bodies, and the attention of astronomers was directed to their possible proper motion which had not before been studied with this view on account of their supposed enormous distance.

Fig. 1.

Similarly, by observation of such comets as have been visible since the development of this process, it has been shown that, while the light emitted by the tails is probably due to reflected sunlight, that coming from the nucleous is of gaseous origin. Thus, the comet II. of 1868 gives a spectrum such as is seen in Fig. 2, and corresponding exactly with that of ignited carbon vapor.

Fig. 2.

Unfortunately, the supply of comets during the last year or two has been small, and not of a brilliant character, the only other which admitted of spectroscopic study being Brorson's, which was of small size and gave the spectrum (shown in Fig. 3) which has not yet been identified.

Fig. 3.

The next general principle or law of spectrum analysis may be thus stated. Each substance will absorb exactly those kinds of light which it emits when self-luminous. Thus, as we have seen, sodium vapor emits essentially pure yellow light of a character which we may more exactly express by saying that its rate of vibration is 527,000,000,000,000 times per second. If, now, a ray of white light is caused to go through a mass of sodium vapor, all the colors will pass freely except the yellow, whose vibrations are at the rate mentioned above. These will be absorbed by the vapor, and, while adding to its general luminosity, will be abstracted from the traversing beam, so that when it is subsequently separated by a prism into its constituent colors, in the manner described in our first article, the yellow will be wanting, and thus, in the spectrum produced, a black space or line will appear in the yellow part.

This is not a meaningless, unreasonable or isolated rule, but one

which is a natural deduction from general principles, and in accordance with the universal laws of mechanics.

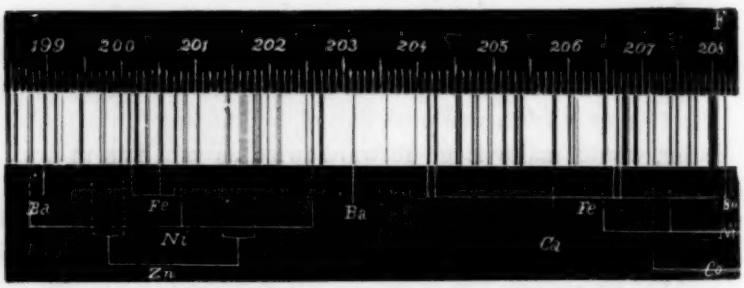
This we will endeavor to make plain. Keeping in mind that light is simply a rapid vibratory motion, it is clear that if a substance is capable of emitting exclusively one color of light,—that is, vibrations of one particular rate alone,—this must be because its particles are so constituted that they can only vibrate at this rate. So is it with a piano-string: it always gives one note, because its length, weight and tension are so adjusted that it can vibrate at one rate and no other. If, now, a series of vibrations following each other at exactly this rate strike upon this string, they will communicate their motion to it, because the first will give it a little impulse, too slight to be perceptible, but yet something, and the second will arrive just in time to add to this at the next swing, and the third again in its turn, until the accumulated effect becomes sensible. Thus with a swing. Suppose that a swing was of such a length that it made its full vibration forward and back again in three seconds (this would require it to be about twenty-nine feet and three inches long), and that we gave it a series of light pushes exactly three seconds apart. The first push would move it a little, and it would sway forward and then come back beyond where it started, and would then (exactly three seconds after the first push) be about to move forward again without external aid; but exactly at this instant would come push second, and adding to the acquired impulse, would make it go forward twice as much as at first, so that it would come back again twice as far, and so be ready at the end of the second three seconds to start forward with a double impulse; but at this auspicious moment would come the third push to add to this motion, and so on. Thus, a series of impulses, each alone too small to produce a sensible effect, would thus, properly timed, aid each other and accumulate motion, as it were, in the vibrating body.

I assume that my readers are aware of the fact, first observed by Galileo in watching a hanging lamp in church, that within moderate limits, a pendulum of a fixed length vibrates in the same time whether it moves through a great arc or a small one. When it goes far it goes fast; when a short distance, slow,—just so as to keep the time of the swing or beat constant.

But let us suppose that the pushes to the swing were given every two seconds; then the second push would meet the swing just as

it was one-third way back on its return motion, and nearly the entire force of this second push would be then expended in checking the return motion, and the swing would almost come to rest. The third push would then start it again, but only to be stopped by the fourth, and so on. It is clear that the discord, the want of equal timing in the vibrating body and the source of motion, will prevent a transfer of this motion from one to the other. This may be demonstrated in various ways. Let a tuning-fork be set upright in a stand on a table. Then sound another which is in exact accord and bring it near the first for a moment. On removing the second fork, we will find that the first is singing. The sonorous waves in the air, developed by the second fork, struck the other just at the right time after one another. But if the same experiment is tried with forks differing ever so little in pitch, no motion will be communicated. Exactly so is it with the vibrations of light. If a ray, containing all rates, falls upon a body capable of vibrating but at one rate, the vibrations of that rate are transferred to the body as above described, while the others travel on unaffected.

Fig. 4.



It will thus be seen that the property of "elective absorption" is not only capable of explanation, but is even a natural deduction and consequence of the undulatory theory of light.

Bunsen and Kirchhoff were the first, however, to discover this fact, and by a careful series of experiments, not only to establish its universal truth, but also to apply it to the most wonderful investigations. Thus, by a comparison of the black lines found in the solar spectrum, with the bright ones developed by various elements, they showed that our luminary contained in his atmosphere, hydrogen, sodium, iron, magnesium, calcium, copper, cobalt, barium, nickel, and that, on the other hand, mercury, lithium, copper, silver,

zinc, tin, lead, antimony, alluminum, cadmium, etc., were absent. Thus accomplishing the incredible feat of analyzing a body which was more than ninety millions of miles away, and which it would take us about three years to reach, if we could travel towards it at the rate with which a cannon-ball leaves the mouth of a cannon.

Fig. 4 represents a small part (about one-twelfth) of the chart of the solar spectrum prepared by Kirchhoff. The central band shows the lines observed in the solar spectrum. The diversions above are those of an arbitrary scale employed by this observer. The letter F indicates a very strong band in the greenish-blue of the spectrum, before observed and so named by Fraunhofer, and corresponding with one of the bright lines produced by hydrogen. The light lines on a black ground below, indicate the positions of bright bands produced by various elements in which the coincidence of some and want of coincidence in others with the lines of the spectrum above, are evident on inspection. The chemical symbols of the elements are used to indicate them. Thus Fe stands for iron, Ni. for nickel, Co. for cobalt, Ca. for calcium, Zn. for zinc, and Ba. for barium.

(To be continued.)

SPECTROSCOPIC NOTES.

By Prof. C. A. Young, of Dartmouth College.

In observing the spectrum of the chromosphere, I find two bright lines, not heretofore observed so far as I know. The first corresponds exactly to a small dark line, 1474 of Kirchhoff's scale near E, given both by him and Angstrom, as an iron line. It is difficult to see, and is not noticeable in the spectrum of the protuberances, but only in that part of the chromosphere close to the body of the sun. It is best seen by using power enough on the telescope to get an image of the sun about six inches in diameter, and placing the edge of the disc just *tangent* to the slit of the spectroscope collimator. It was first recognized July 8.

The other line is at (or very near) 664 of Kirchhoff's scale, between B and C. I have seen it only twice, both times in the spectrum of a protuberance. The first time (June 25), though only seen a few moments, it was bright and distinct. As seen again to-day, it was much fainter, but I think unmistakable.

The instrument employed consists of a comet-seeker of 4 inches

aperture, and 30 inches focal length, provided with a spectroscope of 5 glass prisms of 45°; the spectroscope having an aperture of 2¼ inches, and 17 inches focal length. The whole apparatus is mounted equatorially.

The forms of the protuberances as seen by merely opening the slit, and looking at them through the C line (which appears then like a chink through which one looks out upon sunset sky), are very beautiful and fantastic, closely analogous to the light cirrus clouds of a spring or winter day, and varying nearly as fast. An hour sometimes almost wholly changes one. There are commonly four or five of them on the edge of the sun's disc at once. Usually, the chromosphere is found all around the sun with an average depth of from 15 to 30 seconds. To-day (July 19), a place was observed where the chromosphere was hardly perceptible; it was not more than 5 seconds deep, and very faint at that. Its position was on the south-east edge of the disc, 128° from the north point, very near a spot of considerable size, which had only advanced a few minutes of arc upon the limb. May not this deficiency in the chromosphere indicate the precise position of a spot just coming round the limb?

Dartmouth College, July 19, 1869.

CAMPHORIC ACID AND SOME OF ITS COMBINATIONS.

By Robert Fairthorne, Esq.

Not having been able to find any full description either of camphoric acid or its salts, I thought that perhaps others might have met with a similar disappointment and that the following communication would not be out of place in this *Journal*.

By repeated distillation of camphor with nitric acid, that hydrocarbon is converted into camphoric acid by absorption of six equivalents of oxygen, two of which appear to unite with two atoms of hydrogen, differing therefore from camphor, not only by the addition of the oxygen, but by two equivalents of the hydrogen being abstracted. The composition of camphor being $C_{20}\ H_{16}\ O_2$, that of camphoric acid is $C_{20}\ H_{14}\ O_6 + 2\ H\ O$.

The combinations of this acid with the alkaline or metallic oxides are peculiar, and possess considerable beauty of form. I shall strive, however, to describe the appearance of the acid first.

The crystals from the nitric acid solution generally arrange themselves in shining, white, transparent tufts, having a hemispheroidal shape, the flat surfaces of which float on the top of the nitric acid solution, whilst prismatic crystals radiate downwards from central points in the disks.

A still stranger form of crystallization is sometimes produced from its solution in the same acid, for which I have been at a loss to account.

It takes the form of minute opaque, white, leaf-like crystals, have a close resemblance to elaborately carved ivory, each crystal being about the eighth of an inch long and about the twenty-fourth of an inch wide across the centre, and of an ovate form.

From its alcoholic solution it solidifies in stellular transparent crystals.

As obtained from its ethereal solution it is found not only as just described, but in long prisms also, having terminations which have somewhat of a feathery appearance.

It dissolves freely in alcohol and ether but is insoluble in benzine and chloroform. It is soluble to a moderate extent in water above 150° F., and to a small extent in cold water. It combines readily with ammonia and the other alkalies. The ammonia salt crystallizes in silky star-like crystals, having a peculiar appearance.

The aqueous solution of this salt reacts in the following manner with the articles hereafter named. With solution of the sesquioxide of iron a light brown precipitate with a reddish hue is thrown down. It might almost be described as of a flesh color. The same result follows when mixed with the solution of the sesquisulphate. When added to the solutions of the proto-salts of iron no precipitation occurs.

Mixed with the solutions of the sulphate of copper, a bright green precipitate is thrown down. Even with a solution containing so small a quantity of the sulphate as one grain in the pint, a decidedly marked color is produced, after allowing the mixture to stand for a few minutes. This color is so peculiar that I would propose it as a test for copper.

With solutions of salts of lead a dense white precipitate is formed. With solutions of salts of mercury a similar precipitate is formed, and with the following solutions no precipitation is apparent, namely, with that of sulphate of zinc, of sulphate of morphia, of sulphate of